MECHANICAL ENGINEERING

August 1933

IS GALLOWAY, N.Y.

BAILEY METERS

10% of Coal Cost SAVED at Celina with Bailey Meters

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Department of Public Service

W. R. COOK, City Manager
PAULINE BOMERSLL, Cashier
JOSEPHINE DEPWEG, Asst. Cashier

CELINA, OHIO
June 1, 1933

Bailey Meter Company
1050 Ivanhoe Road
Cleveland
Ohio

Gentlemen:

In the year 1931, we had installed in our Municipal Electric Light and Water Plant, three of your Bailey steam and air flow meters on our three 300 horse power water tube boilers. We weigh all of the coal that we use daily, and we have found that we have been able to reduce our coal cost approximately ten per cent by the use of these meters.

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Yours very truly,
DEPARTMENT OF PUBLIC SERVICE
W. R. Cook
W.R. COOK
CITY MANAGER

WRC*J

THE accompanying letter from Mr. W. R. Cook, City Mgr. of Celina, Ohio, tells how Bailey Boiler Meters have reduced coal costs 10% on the three 300 h. p. water tube boilers in their Municipal Electric Light and Water plant.

The Municipal Plant at the City of Celina is just one of the many municipal, industrial and institutional power plants which are making worthwhile savings by the use of Bailey Boiler Meters.

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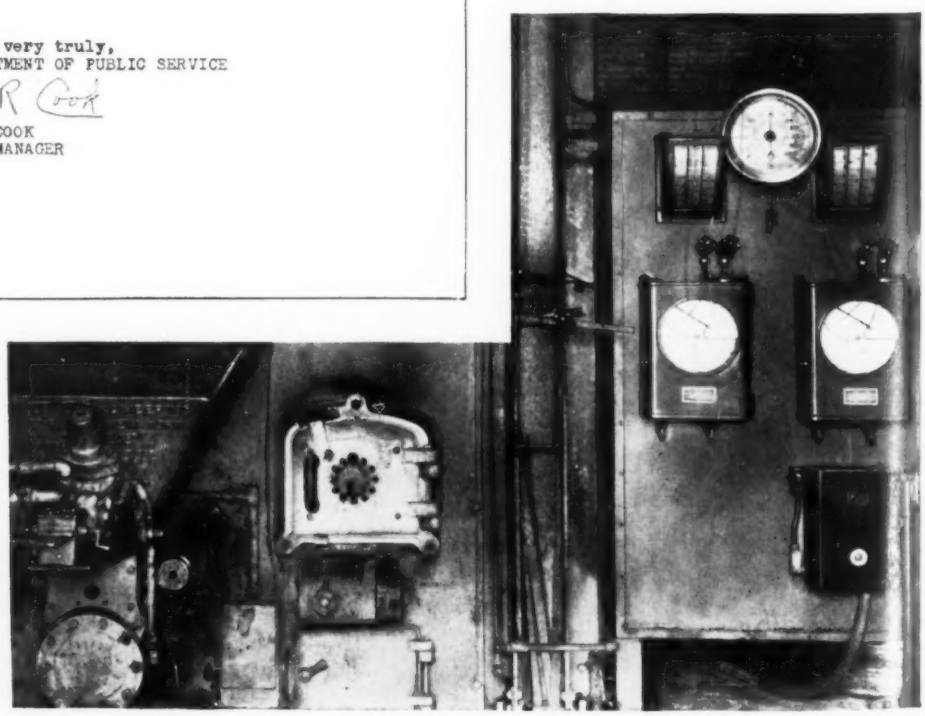
BAILEY METER CO.

1026 Ivanhoe Road, Cleveland, Ohio



Two of the three Bailey Boiler Meters installed on 300 h. p. boilers at Municipal Electric Light and Water Plant, Celina, Ohio

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 55 NUMBER 8

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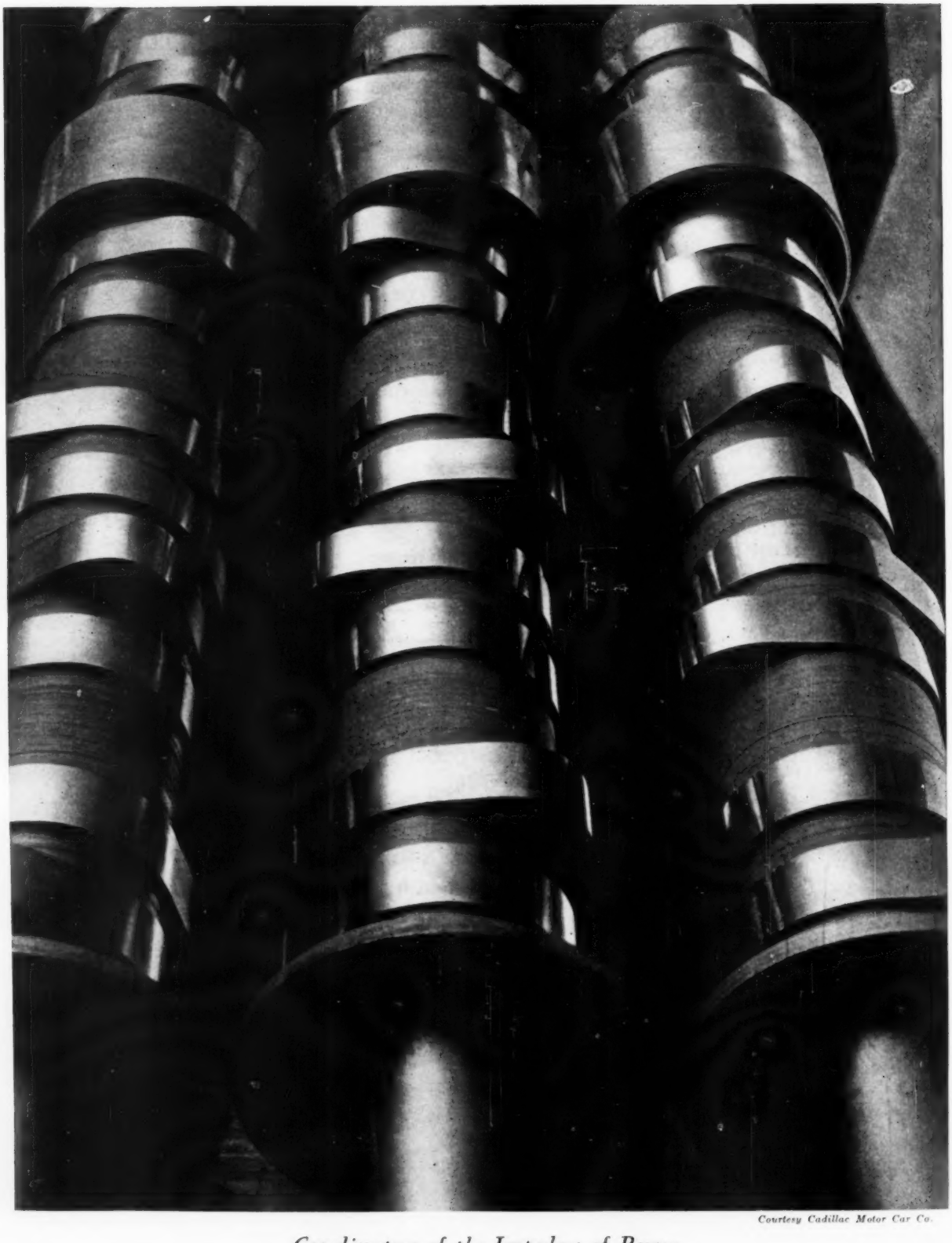
Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1933, by The American Society of Mechanical Engineers.



Courtesy Cadillac Motor Car Co.

Coordinators of the Impulses of Power

An ENGINEERING APPROACH *to* GOVERNMENT

By WILLIAM BEARD[1]

"QUEBEC BRIDGE crashes, 80 dead!" "St. Francis Dam collapse drowns scores!" So scream the headlines when an important engineering project fails through neglect of natural laws. And rightly so, for the exceeding rarity of such events turns them into sensational news. From this situation we may properly draw the conclusion that engineers, in general, remain under rigid professional discipline. Dealing with the known properties of materials and forces, they do not often let their emotions side-track them from a rational and planful line of scientific thought. In their narrow technical field they are distinctly successful.

When dealing with politics rather than physics, however, it must be admitted that the technician has not been quite so victorious. "The storms of sentiment or of prejudice," says Mr. F. H. Newell, former director of the Federal Reclamation Service, "may be as destructive to a well-planned work as is the wind or flood." Failure to master governmental situations, then, often spells temporary defeat. Our giant Muscle Shoals project has stood substantially idle for more than a decade, while heated debates as to the relative merits of private and public operation resounded through the halls of Congress. It took a quarter of a century to resolve a bitter conflict centering about the division of water rights between seven Western states before the construction of Boulder Dam could be started. Chicago sewage-treatment and other works have suffered severe setbacks as a result of financial shortages arising out of a bad tax muddle in Cook County, Ill. The reader can undoubtedly greatly expand the list himself.

Nesmith

POLITICAL OBSTRUCTIONS TO ENGINEERING PROGRESS

It being the task of the engineer to carry his plans through to completion, it is incumbent upon him to inquire into the causes of the various political situations which block his progress. What is wrong? Sometimes the technician himself is at fault. Maybe he is thinking primarily of himself, urging expensive inland waterways or other improvements to make work for construction outfits, without sufficient regard for the economic advisability of the undertakings. Or maybe he seeks license restrictions for his profession to protect himself rather than the public. When the Metropolitan Water District of Southern California was considering tapping the Colorado River, below Boulder Dam, to relieve an alleged shortage from underground sources, there was a dispute as to the merits of the project. On one side, it was claimed that the impounded waters would be excellent. On the other, it was contended that the artificial lake in the system at Boulder Dam would flood salt beds, rendering the contents so saline as to be quite unfit for human consumption. Both propositions could not be simultaneously correct. Special interests had found experts willing to warp the truth for their own ends. Was the Muscle Shoals nitrate equipment suitable for use a few years ago, or was it obsolete? Public hearings revealed a maze of conflicting testimony from men aligned for and against a bill contemplating public operation. It is not easy to place professional ethics above the struggle for a living. But until public confidence can be gained for his every word, the engineer should not too roundly blame the politicians and the people for their outbursts of opposition to his proposals.

Frequently the difficulty lies with the political scientist and not the engineer. The former approaches the subject of government mainly from the point of view of history, law, and philosophy. He does not take a direct, rational, efficient route to achieve his end. Instead, his winding detours confound and confuse. Before supporting subsidies to encourage the building of air-mail planes, he consults dusty tomes revealing what the fathers of the Constitution thought about the carriage of mail by horse. Before deciding upon the best mode of procedure in the licensing of radio stations, he reads century-old articles on interstate commerce in firewood, wines, and cheese. He applies fugitive game laws to

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Ewing Galloway

property rights in oil and gas pockets underground. He examines ancient rules for short rivers in the British Isles, where tidewater was under the control of the King and comprised almost all navigable inland routes. Then he tries to apply the same principles to giant American rivers where tidewater is of almost no significance. He comments upon Greek ideals as to democracy versus dictatorship in an agricultural civilization, recommending these doctrines to citizens of a technological era, wrecked by unemployment, wildcat financing, and wasteful competition. He extols the Spartan doctrine of war as a manly exercise in a decade of poison gas, trenches, machine guns, and air raids. No wonder the government under which we operate remains out of step with mechanical progress. No wonder it interferes with the pretty blueprints of the engineer.

APPLYING THE SCIENTIFIC METHOD TO THE CONDUCT OF GOVERNMENT

Remedial steps should take the form of applying the scientific method to the whole sphere of government, to bring it into resonance with modern technology. What purpose is to be achieved? What plans should be made to attain the desired results? How may they be put into effect with an absolute minimum of lost motion? A few instances of such good practise are already in evidence. Operating on a local scale, official city-planning bodies have divided scores of metropolitan areas into "use" zones, prescribing limitations on the height, bulk, and shape of structures. Hodgepodges of factories, homes, and stores are being vanquished. Public-utility companies find their calculations simplified, as definite residential or other restrictions on given sections permit them to estimate probable loads on mains with reasonable accuracy. Traffic congestion is partially relieved. Even beauty is affected. Similar activities are being pushed in counties and other regions. State planning has been born, a few reports on the subject being now available. Boldest of all is the National Industrial Recovery Act which establishes national supervision of our commercial life. Trade associations, drawing up binding rules for their members, are regulated and assisted by Washington authorities. It is hoped that a marked reduction in destructive competition will result.

There is room for further scientific planning all about us. To be concrete, governmental authority is now divided between Federal, state, and local units in accordance with the requirements of an ox-cart and tallow-dip society. Boundaries and privileges were assigned the various bodies that bear slight relation to modern congeries of watersheds, oil pockets, and the like. No wonder petroleum is found in large amounts in a half-dozen states, and that when one tries to conserve its supply, the others contrive to take advantage of the reduced flow to release floods of their own. No wonder sanitation on the Ohio River, involving water-supply and sewage-disposal systems in several states, is in a chaotic condition. Chicago drained the Great Lakes to solve a local disposal problem, lowering harbor depths in adjoining areas to the detriment of shipping. Oklahoma and Texas declared martial law in a fight over the opening of a modest interstate highway bridge across the Red River. Each state devises its own laws as to the design of motor cars, as to traffic practises, and road signs. A truck piled high with furniture snapped a farmer's 'phone wire. As a member of the legislature, he succeeded in reducing arbitrarily the size of all trucks in the state. Repeated attempts to secure reasonable uniformity in legislation in the 48 states meet with monotonously regular defeat. Provincialism is playing havoc today with continental development.

NATIONAL PROBLEMS CALL FOR NATIONAL CONTROL

Reform should take the direction of a redistribution of powers between units on the basis of engineering rationality. If a problem is truly national in scope, then let it be nationally managed. As long as direct action, in the form of constitutional revision, remains remote from the realm of practical politics, subterfuge may be employed. Already a truly continental system of trunk highways of standard design has been created through offers of financial aid to states on condition that they accept Federal direction in return. "Bribery" is not always necessary. State after state has voluntarily made it illegal to engage in local flying without complying with Federal aviation requirements for planes, pilots, and mechanics. Sudden changes in these rules thus automatically become effective in a series of jurisdictions. Where resulting concentrations of power in Washington tend toward an unwieldy bureaucracy, standards may be set at the Capitol and enforcement left in local hands, after the Swiss manner. Conversely, where situations are purely local in scope, they should remain in local hands. Regional problems, neither purely local nor purely national in character, but involving several cities, counties, or states, may be dealt with in either of two ways. They may be handled by a unit of government comprehending the whole area, or a special district may be established, whose boundaries and powers are perfectly molded to the task at hand. The latter expedient has been tried on innumerable occasions, as scores of sanitary, irrigation, drainage, flood-control, and other engineering developments bear witness.

INCREASING NUMBER OF TECHNOLOGICAL PROBLEMS REQUIRING LEGISLATIVE ATTENTION

Turning to individual governments in detail, further anomalies appear. As policy-determining bodies, American legislatures are faced with a steadily growing mass of problems, many of them the consequences of continued technological progress. There are interstate buses to be regulated, oil to be conserved, reforestation to be encouraged, flood control to be promoted, public works to be planned, railroads to be revived, unemployed to be relieved, and budgets to be balanced. Yet important measures are often side-tracked while petty details are given the clear signal. One instance, picked at random, shows the difficulty. A bill was introduced in Congress some time ago to reimburse a farmer for the price of a Jersey cow. The cow, according to the *Congressional Record*, had consumed the contents of a can of paint left near her by some engineers at work on a Federal stream-gaging station, reducing the bovine population by one. Altogether too much time is spent in dealing with such minutiae.

Several concrete schemes of relief are possible. Petty claims might be gone over by a special officer whose proposed disbursements could be passed upon in one lump sum. Innumerable technical rules controlling engineering design, such as the legal minimum strength for boiler plate on steamers, or the proper stopping distance for automobiles upon the application of their brakes, might well be formulated by expert technical administrators rather than by legislative bodies. This avenue of escape has been tried with success in the field of aviation. Under blanket authorization from Congress, the Department of Commerce has drawn up and revised from time to time a mass of specifications as to the construction and operation of aircraft. Even scientific devices could be of service. At present the roll is called by voice, with a consequent loss of many precious hours annually. Through the installation of electric recording apparatus, the presence of a quorum or the vote of members on a bill could be almost instantaneously determined. Eighty-three days might have been saved in the 62nd and 63rd Congresses alone by this means.

UNWIELDINESS OF BUREAUCRATIC ORGANIZATION

Executive organization, too, comes in for a share of criticism, its fault being unwieldiness. To take care of one new technical development after another, agencies have been added to the political structure with startling rapidity. Progress in electric light and power transmission, communication, and rail service brought about the creation of a multitude of utility commissions. As factories turned out floods of automobiles, highway departments were hurriedly established, squads of motorcycle police put on the road, and licensing centers founded. Building inspection, water filtration, sewage treatment, and a host of other activities swell the sum total of duties. Growing by steady accretion, governments became a maze of independent, overlapping, and unrelated units. Red-tape and inefficiency followed. Then came the reaction. With the strong encouragement of several privately endowed research institutions, such as the New York Bureau of Municipal Research, scores of cities, counties, and states have reexamined their administrative set-ups. Bureaus have been shifted, and consolidated into a few integrated departments. Boards have been replaced by single heads. Duplications have been eliminated, lines of responsibility have been cleared, and costs have been cut. A voluminous and growing literature records encouraging progress in this direction.

Ewing Galloway

JUDICIAL PRACTISE AFFECTED BY TECHNOLOGY

Judicial practises also feel the impacts of technology. There is, for example, the question of competence. Judges often have slight knowledge of engineering problems coming before them, however conversant they may be with the applicable law. Juries, picked by lot, are even more bewildered by expert witnesses. Finally, ordinary court routine, with its formal rules of procedure, can prevent the clear presentation of scientific facts. What can be done by way of improvement?

Judges have sometimes adopted the plan of employing consultants, known as special masters. During the fracas over Chicago's diversion of water from the Great Lakes, for instance, such an agent conducted preliminary hearings on engineering facts, and wrote up his recommendations for the guidance of the whole court. On numerous occasions juries are being eliminated. However, little is being done at present to simplify procedure. To overcome difficulties from this source, resort may be had to commercial arbitration.

Under the laws of several states, contracts may be made binding signatories to resort to arbitration in case of dispute. When an argument arises, a board of impartial experts is chosen to take testimony from both sides. At the close of the hearing, a decision is rendered, having the force of a regular court order. Philadelphia used it in a tussle with contractors over subway work. The system has possibilities. The growth of administrative bodies, serving as tribunals, is also encouraging. Among them is the Federal Board of Steamboat Inspectors, hearing technical cases involving such matters as as shipwrecks.

CHANGES IN PATENT LAW AND PROCEDURE NEEDED

Certain great institutions, such as the patent system, are in need of reform. At the present time, according to one writer on the subject, a patent is little more than a permit to engage in litigation. Questions as to validity, infringement, or sale are continually cropping up. Frequently the costs of legal service are such that the inventor is bankrupted rather than rewarded for his aid to mankind. Even if he wins a verdict, his opponent may not be financially capable of paying damages. No wonder the mere suggestion of a lawsuit is often sufficient to frighten individuals and companies into quiet settlements. Where an attempt is made to avoid court snares by forming large patent combines, a further problem arises—the anti-trust laws forbid monopolies while the patent laws encourage them. Before the bar, many an integration of patent monopolies has crashed to the ground as an unfair restraint of trade. Since patents touch the very roots of our industrial society, the tangle assumes major proportions. Many costly errors might be eliminated through increasing the size and salaries of the staff of patent examiners. A separate court, having to do with nothing but patent cases, has been proposed as a means of simplifying procedure after issuance. Finally, the new National Recovery Act, with its relaxation of the anti-trust laws, may offer a solution to the patent-combine situation.

EFFECTS OF TECHNOLOGY ON MONETARY METALS

Governments, struggling with the problem of creating a sound currency, must reckon with technology. Turning to the gold situation, we find marked fluctuations in output from time to time. The advent of the cyanide process caused a big spurt. Conversely, increasingly high rock temperatures encountered by workmen, as they penetrate deeper and deeper into South African fields, tend to impede operations. With the supply shifting in amount from year to year, the market value of gold, in terms of other commodities, is anything but steady. Trying to tame the dollar, President Roosevelt recently won from Congress the power to alter its gold content by as much as 50 per cent.

Whether enough gold can be obtained to serve as a basis for world exchange in the future constitutes a second major question, as our anti-hoarding rules indicate. But the bimetallist is not discouraged; he envisages vast supplementary reserves of silver. However, silver is obtained largely as a by-product of plants turning out baser metals. Its metallurgy is, then, quite distinct from that of gold. Furthermore, the industrial demand for gold is very different from that for silver. There seems to be little if any physical reason why the two might remain on a parity in value. History proves the dreams of bimetallists, in this connection, to be idle fancies. No wonder certain economists tire of the muddle and suggest drastic new policies. Most radical of their doctrines is the plan for eliminating metal backing altogether, and substituting paper money whose volume and value might be coordinated with shifts in commodity price indexes. Certainly we shall have to try some such ingenious scheme if we are to have a truly stable currency.

Elizabeth R. Hibbs

ENGINEERS CAN ASSIST IN SECURING BETTER GOVERNMENT

How can changes, such as those suggested above, be brought to fruition? Engineers themselves constitute one powerful agency for reform. Once fearful of dealing with matters outside of their limited professional fields, they now realize a still greater danger to success that lies in a narrowed vision. Some time ago, through the National Public Works Department Association, they sought to effect a partial reorganization of our Federal administrative structure. True, it was not broad enough in scope, and ultimately failed, but it was a step in the right direction. When Cook County got into dire straits, as a result of the Chicago tax muddle, a group of engineers proposed a simplified political set-up to reduce expenses. With the country in distress, with millions out of work, and with technicians receiving their share of the blame, MECHANICAL ENGINEERING has distinguished itself by publishing a notable series of articles on political and other phases of recovery.

Unfortunately the movement for a reconsideration of modern government in the cold light of engineering rationality, already begun by the professional societies, has awakened few responses from our technical schools. While courses in mechanism, electricity, power-plant design, aeronautics, and the rest must be constantly revised to keep pace with invention, no such progressive compulsion is felt by the average political-science instructor. Trained in the traditional manner to concern himself with the origins of democracy, the composition of legislatures, states' rights, the veto privileges of the executive, and similar matters, he often fails to reckon with the technological changes that are taking place about him. Meanwhile, we approach an impasse. The hour has come for an adjustment of thought to action. Ways and means of making technology work, in a broad human sense, must be devised. Young engineers must be led to think about government as a dynamic entity which can be made the servant of great designs, rather than an accumulation of historic traditions. Failing this, we must prepare for a deadlock on one vital front. If we continue to be tied up, there are thousands of willing hands, ready to sweep us back toward the simple life of the past which is within the range of our mentality.

The ENGINEERING ECONOMIST *of the* FUTURE

By DEXTER S. KIMBALL[1]

TO THE engineer trained in the explicit solution of problems, basing such solutions on fairly well-known facts and experiences, the wide divergence of opinion among statesmen and economists on so many economic problems as are now before us is certainly a cause for wonder, if not amazement. It does not seem possible that after so many years of study of economics on the part of so many able men and with the vast literature on this subject now available, there should be such violent disagreement among economists on such matters as inflation, the gold standard, etc., the discussion of which now fills the land with raucous debate.

During the past year or more, the author, as a member of a committee of the American Engineering Council, has read a large number of essays by persons in many walks of life, including many professional economists, all offering explanations of our present industrial predicament, and many offering solutions of existing troubles. The general impression that he obtains from such an experience is that practically all of these literary efforts are based largely upon *opinion* and little upon proved *principles*. And while in the aggregate they contain much wisdom and many good suggestions, they do not either collectively or individually present a clear picture of the problem, to say nothing of a definite solution of it. One is moved, therefore, to ponder the character of economic thought and the place that science and engineering may and should occupy in that field.

CHANGE IN ECONOMICS OF PRODUCTION SINCE THE DAYS OF ADAM SMITH

An authoritative encyclopedia defines economics as "the science that investigates the conditions and laws affecting the production, distribution, and consumption of wealth or the material means of satisfying human desires; political economy." Viewing our present uncertain condition, it might well be doubted that economics is at present a "science." The hallmark of a science is the ability to predict, and most certainly the wide divergence of opinion among leading economists does not lend confidence to their predictions. However, that is beside the present question.

Consider, first, the field of production. Until well along into the eighteenth century, the world had made its living solely by handicraft; indeed, a large amount of handicraft still survives. Adam Smith's great masterpiece, "The Wealth of Nations," which is generally conceded to be the foundation of modern economics, was published in 1776, some years before Hargreaves invented his epoch-making "spinning-jenny," and about the time that Watt built his first imperfect steam engine. Quite naturally, this great philosopher viewed industry as handicraft, and while many of his conclusions on some topics may still apply, the economics of production have been greatly changed since his day.

In a rapidly moving age such as ours, most economic prophecies should be taken with a grain of salt and most economic prophets looked on with some suspicion. And if the engineer is to venture into these troubled waters with the idea of applying his well-tried scientific methods, he should take thought also of the measure and limitations of these methods, as otherwise he may bring discredit not only upon himself but upon the group that he represents.

During the years 1800–1850, the engineer was busy building up the modern tools of industry. As an economist, he was a negligible quantity. With the development of the semi-automatic and full-automatic machine in this country, about the middle of the century, modern manufacturing methods came into being, but it was a quarter of a century before the new economic relations introduced by these methods attracted the attention of engineers. About that time, however, engineers began to assume prominence as industrial managers, and quite naturally they turned their scientific training to the consideration of the economic problems occasioned by the new methods. In 1886, Henry R. Towne presented a paper before The American Society of Mechanical Engineers entitled, "The Engineer as an Economist."[2] In

[1] Dean, College of Engineering, Cornell University, Ithaca, N. Y. Past-President, A.S.M.E.

An address delivered at a joint meeting of the Econometric Society, and the A.S.M.E., A.I.E.E., and A.S.T.M., Chicago, Ill., June 29, 1933. See also pp. 486–492 of this issue.

[2] Trans. A.S.M.E., vol. 7 (1886), p. 428.

this remarkable paper, Mr. Towne foreshadows the coming development in industrial economics and suggests that as a means of furthering this movement, a new division of the society be formed, to be known as the Economic Section. It was thirty years or more, however, before this idea took strong root in the society, though occasionally there appeared some evidence of progress, such as F. A. Halsey's monumental paper, in 1891, on premium wage systems.[3] Near the end of the century, this growth culminated in the remarkable work of F. W. Taylor and his associates, Gantt, Gilbreth, Barth, and others, which ushered in a new era, not only in factory work, but in management in general, whether in farm, factory, shop, or government.

Whereas forty years ago industrial production was almost entirely empirical, today the economic principles of production and their limitations are quite fully determined, though it must be admitted that this knowledge is not as widely disseminated or used as it should be. But the outstanding fact remains that the engineer of today has quite complete mastery over the economics of production and can predict with some certainty, not only the scientific characteristics of his product, but also its economic performance. And it should be specially noted that in so doing he has developed a knowledge and a control of the human element in industry that would have appeared to be impossible fifty years ago. For the most part, this extended knowledge of modern industry is the exclusive property of the engineering profession.

As a result of this industrial development, both in factory and farm implements, of scientific agriculture and modern methods of food preservation, we are now able to produce the necessities of life in an abundance never before dreamed of. If poverty or want of any kind exists, it is not for lack of either material resources or facilities for developing them to our use. It is generally conceded that about 1900 we passed from a "deficit economy" to a "surplus economy," or from a "seller's market" to a "buyer's market," and for the first time in the history of man there was a hope that poverty could be abolished. For a time it appeared that we had solved this age-old problem, only to be cast into one of the worst depressions in our history. And as we emerge from the dust and débris of this debacle, it is little wonder that the land is filled with discordant voices seeking the cause and cure of this reverse of fortune.

If the industrial, commercial, and financial world had remained as simple as it was, say, in 1885, our hopes of solving the problem of existence might have been fulfilled. But in developing these new industrial methods, the engineer has also developed a most remarkable system of transportation, both on sea and land, and to this he has added the telegraph and the telephone which, with the modern newspaper, have literally abolished distance and brought the world to every man's breakfast table. The net result is a social and economic system as sensitive as it is complex. Worse still, this system apparently has greatly increased the opportunities for graft, exploitation, and unfair business and legal methods, which appear at times to defy all law and authority. This statement may be questioned in the light of days gone by, but at any rate the new methods have interposed between producer and consumer a system of distribution more complex than any heretofore known, and one that calls for immediate remedies. The remedial efforts needed are ethical, legal, and economic in their scope. We are not here concerned with the first, and we are interested only in the second in so far as it affects economic considerations.

[3] "The Premium Plan of Paying for Labor," by F. A. Halsey. Trans. A.S.M.E., vol. 12 (1891), p. 755.

THE ENGINEER IN THE FIELD OF INDUSTRIAL MANAGEMENT

Adjoining the field of actual production and closely integrated with it lies the field of industrial management. This may be visualized as embracing the managerial functions in productive industries, transportation, and sales. The engineer has been prominent as a manager of productive enterprises ever since the industrial revolution, but in recent years his activities in this direction have been greatly increased and widened, due primarily to the increase in the scientific background of all industrial and related fields. His superiority as an administrator, other things being equal, lies in his scientific training and his intimate knowledge of industrial operations. When to these is added a knowledge of accounting and finance, the combination is the very best that can be had for work in industrial administration of any kind.

The engineer's usefulness in this territory has been widely attested by the writings of individual engineers, by the work of committees of national engineering societies, and most particularly by the work of the American Engineering Council which was organized specifically to give voice to the idea of engineers on economic topics on which they are, by experience and training, specially fitted to express an opinion. This usefulness has also been recognized in the appointment of engineers to the Reconstruction Finance Corporation and more recently by the appointment of Mr. Arthur E. Morgan as head of the Tennessee Valley Authority.

Now it is in this part of our industrial life that our greatest difficulties lie and where greatest reforms are needed. Certainly it cannot be claimed that industry as a whole has been well managed or well financed, judging by the very large number of enterprises seriously handicapped by interest on bank loans. Our transportation system, which grew up under *laissez faire* conditions, is chaotic and fails to function as a national service, and the entire system of distributing industrial and agricultural products and marketing them is unorganized and costly to an extreme. It is in this area also that, apparently, we are embarking upon some important experiments, as the much discussed National Industrial Recovery Act testifies. It is not to be expected that the engineer can formulate solutions for these far-reaching problems, but without doubt, if he rises to his highest usefulness and prepares himself through study of these problems, he can make a helpful contribution to the economics of this phase of our industrial life. Not all of

them will lend themselves to the concise and accurate methods that he has employed in production, but in many cases the analytical methods of engineering will prove very helpful.

THE BROADER FIELD OF POLITICAL ECONOMY

Beyond the confines of this field again lie the broader problems which we include in the term political economy, a field of thought much more vague and much more difficult of comprehension, where the status of the engineer is much more uncertain. It has been asserted quite frequently that the experience of the engineer in industrial economics should give him an advantage in this broader field. It is quite true that the engineering administrator is brought into close contact with such matters as taxes, tariffs, foreign trade, transportation, financial problems, etc., and it is quite frequently assumed that to these problems he can bring the same methods of solution that have proved to be so successful in production problems. In some instances this is true, as is illustrated by the excellent work already accomplished by the American Engineering Council in fields that a few years ago were unknown to engineers. Without doubt, wherever basic facts can be obtained, engineering methods (which after all are adaptations of the scientific method) are very effective in arriving at accurate conclusions. And if such facts are to be drawn from industrial data, the engineer has a peculiar advantage in finding these facts.

Now in the usual case of engineering economics, the variables involved are related and known quantitatively, at least in some degree, making a direct solution possible. But in the field of general economics, exact facts are often difficult to obtain, and when obtained, their relations are far from obvious. The evidence in general economics may be voluminous, the variables many and conflicting, and what is worse, they may be changing in character. In many such cases, the well-trained business man, or the lawyer, is just as capable, or more so, of drawing an accurate conclusion as any one else. Certainly, the engineer has no advantage here, unless the data are drawn largely from industrial sources with which he is more familiar than are others.

As Prof. Seymour Garrett, himself a well-trained engineer and also a successful teacher of economics, has well said: "I said above that the impossibility of drawing valid conclusions directly from the observation of events applied as well to current as to past economic affairs. I am aware that there is at the present time, and has been for some time past, a disposition to assume generalized theory unimportant. It is assumed that detailed statistical inquiry will reveal truth aided only by common-sense and general information. With this view, engineers, because of the nature of their own work and of their triumphs, have a natural sympathy. They instinctively applaud what they denote as an appeal to facts instead of theory. What they forget, and sometimes do not even sense, is that the problems of engineering and of economics present large differences of kind. This is partly because the phenomena with which engineering deals occur in simpler form than those of economics. It is commonly possible to see without conscious effort just what is the nature of the data needed for a proper solution. Also, the basic generalized theory within which the engineer works has been developed so long since that he uses it automatically and almost unconsciously."

THE ENGINEER MUST STUDY BROADLY BEFORE ENTERING THE FIELD OF POLITICAL ECONOMY

If, then, the engineer is to be an important figure in public affairs, he must acquire a broader technique than that which he ordinarily possesses, and he must inform himself concerning a wide range of subjects of which ordinarily he knows little. Furthermore, he must acquire a wide knowledge of economic history and be able to trace the effect of economic changes over long periods of time. The broad economic problems that now trouble us are not isolated and circumscribed in character; most of them have long histories and many ramifications. It is true that some of the old economic theories developed in a handicraft age do not apply to our modern machine era, and the industrial engineer can do much to show their fallacious character. But on the whole, the engineer who aspires to solve modern economic problems must expect to do an unusual amount of studying before he can replace these old theories with others that are suited to our day and methods. Perhaps no field of knowledge presents such a bewildering array of theories which purport to tie together groups of phenomena more or less vaguely connected. He is indeed a bold man who will speak dogmatically about problems in political economy who has not studied this so-called "dismal science" long and carefully as a preparation. If the engineer can apply his analytical methods to these vague relations and develop the basic facts through his more intimate knowledge of industry, he can indeed become a most useful factor in public life.

THE DANGERS OF DOGMATISM AND PROPHECY

In so doing, however, the engineer should avoid dogmatic statements. In his own chosen field he may be quite dogmatic at times because here he has the power to prophesy and make good on his prophecies. But in the field of general economics he must be more careful. This is particularly true of mathematical deductions as to future trends, such as some of the engineering fraternity are putting forth at this time. Economic variables have an unfortunate habit of changing with new discoveries and changed conditions, and it is very unwise, therefore, to extrapolate any curve involving economic variables. Dr. Thomas Robert Malthus, writing in 1798 his remarkable "Essay on the Principle of Population; or a View of Its Past and Present Effects on Human Happiness; with an Enquiry into Our Prospects Respecting the Future Removal or Mitigation of the Evils Which It Occasions," developed the principle that population increases in a greater ratio than food supplies. Had he been satisfied to leave his law in that form, it would have sufficed. But to accent his state-

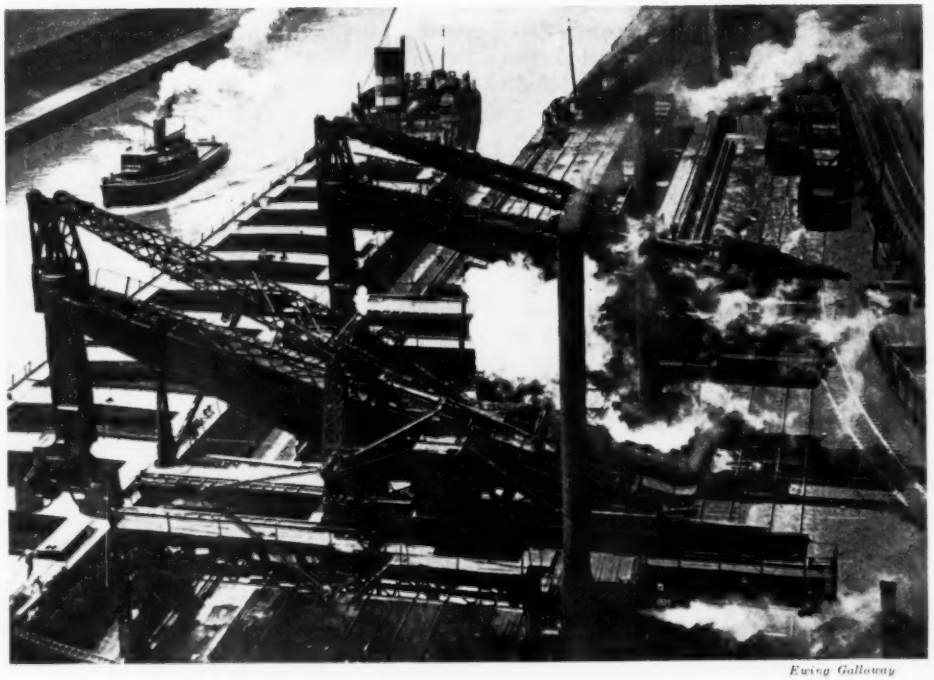
ments he assumes that population *if unchecked* will double every 25 years and hence increase in geometrical ratio, thus, 1, 2, 4, 8, 16, 32, 64, 128, 256; while subsistence in the same time will increase as 1, 2, 3, 4, 5, 6, 7, 8, 9. The dark picture thus presented has had a profound effect upon human thought, and his mathematical statement is so startling that Malthus has come down to us, in the popular mind at least, as a Jeremiah foretelling our eventual death by starvation, rather than as the writer of a treatise on population which is as good and convincing reading now as it was in 1798. Now while undoubtedly the general conclusions of Malthus are correct, the *time* element in his theory has been greatly modified by modern transportation which has made available agricultural areas of which he had little knowledge and by new methods of canning and preserving of food supplies. Who can say that the production of synthetic food may not defer his evil day indefinitely? The more I see of long-time prophecies, therefore, the more I believe industrial prophets might well consider good old Ezekiel, who seldom lacked prophetic power. But when taken by the Lord to view the valley filled with dry bones and on being interrogated by the Lord, "Can these bones live?" Ezekiel, after a careful survey of the situation, replied: "Oh, Lord God, thou knowest!" He would not even venture a guess.

In a rapidly moving age such as ours, most economic prophecies should be taken with a grain of salt and most economic prophets looked on with some suspicion. And if the engineer is to venture into these troubled waters with the idea of applying his well-tried scientific methods, he should take thought also of the measure and limitations of these methods, as otherwise he may bring discredit not only upon himself but upon the group that he represents.

Keystone-Underwood

TENNESSEE RIVER VALLEY FROM SIGNAL MOUNTAIN, NEAR CHATTANOOGA

(President Roosevelt has designated Dr. Arthur E. Morgan, engineer and educator, as head of the Tennessee Valley Authority to develop the region through which the river flows.)



Ewing Galloway

The CONTRIBUTION *of* ENGINEERING *to* PROGRESS

A Brief Review and Evaluation

By EDWARD J. MEHREN[1]

AMERICA this week is witness to a situation which many may consider paradoxic and which is at least dramatic.

On Chicago's Lake Front lies a great World's Fair—from beginning to end a glorification of the scientist and the engineer, an exposition of the physical achievement of the machine age.

To it this week have come America's engineers. But while they look and appraise, while they acclaim and are acclaimed, the world declares that the machine age they have created has failed and is responsible for our present economic and social debacle. "You have contributed to man's leisure, comfort, and convenience," add the challengers, "but the results have been mental flabbiness and weakened morality. There has been no true progress." Such are the charges thrown at the work of the engineer in the very week that he gathers here at the great Fair.

This, then, is the drama that America witnesses: it sees him face to face with his handiwork; it asks what answer he will make, for if his work has failed, so has he.

Here then the challenge must be met; never was the time more opportune.

Has engineering contributed to progress?

Has there *truly* been a century of progress?

THE VICISSITUDES OF PROGRESS

When we speak of progress we mean movement or development in a desirable direction. I conceive that humanity is traveling a long road whose desirable direction and goal are the happiness of all mankind, accompanied, first, by a wide diffusion of this world's goods; second, by the highest order of intellectual development of which individual men are severally capable, and third, by high moral attainment.

But the long road that mankind is traveling is cut by ravines and chasms, some shallow, some deep and precipitous. The ravines and chasms are greed, exploitation, oppression, war, hunger and famine, unsanitary sur-

[1] President, Portland Cement Association, Chicago, Ill.

An address delivered at the joint banquet of all engineering societies participating in Engineering Week at A Century of Progress Exposition, Chicago, Ill., June 28, 1933. Abridged.

roundings, disease, ignorance, vice, and all those other hindrances which interfere with man's progress. At the beginning of recorded history, humanity toiled down into each of the chasms, forded the streams, and toiled up the opposing banks. Progress was slow.

In time, advancement of the arts, better social organization, education and religion, built bridges across the streams, at first only high enough to clear the flood. Further advances raised the bridges to higher levels, made them safer against floods, and reduced both the descent and the upward climb. Could the job ever be completed, we would build a bridge over every chasm from bank top to bank top. The chasms in effect would disappear, and humanity would go forward joyously on a high road—a true *high* way—to its destiny.

Using the simile of the road, our questions can be paraphrased in this way:

"Has engineering helped to build bridges over the chasms, has it raised them to higher levels, has it made them more secure, has it brought nearer that highroad without dips, on which humanity can go forward joyously to happiness, to more uniform enjoyment of this world's goods, to high intellectual and moral attainment?"

CONTRIBUTION TO SOCIAL PROGRESS

Our first inquiry properly relates to the influence of engineering on social progress; that is, on the distribution of wealth, on its effect on men—its effect on them externally and in their relations to others.

We are here not in the realm of conjecture but of fact. We find that in the Western world today, more than ever in man's history, the mass of men are better fed, better clothed, better housed; health is better, life has been prolonged, infant mortality reduced; elementary education well-nigh universal; secondary and advanced education available to all who would have it; liberty greater; opportunity for individual advancement unhampered; justice more equitably distributed. In fine, there is a higher standard of living, and a very high order of social advancement.

The question of wealth deserves special consideration. Wealth today is not only greater in the aggregate, but more widely diffused. The distribution is not entirely equitable, but it is not so disproportionate as those imagine who think only of private property and forget the immense treasury of community wealth. The first is the possession of the individual; the second, the possession of all, for their comfort, convenience, and use. In community wealth never were people richer—in the number and quality of streets and roads, in the purity and amplitude of water supply, in the sanitation and lighting of cities, in fire and police protection, in courts of justice, in medical, educational, and recreational facilities.

How can we account for this increase in the standard of living, this extraordinary social progress, this wide diffusion of wealth?

The explanation lies in a profound but very simple fact that through the engineer's development of power we produce wealth more rapidly today than at any previous period in man's history.

It is this increase in the rate of wealth production that has given us the facilities, conveniences, comforts, and advantages of which I have spoken. To this do we owe our great private and community wealth, our high standard of living, our high level of social advancement.

We must conclude, therefore, that engineering, by increasing the production of wealth, has made an extraordinary contribution to man's social progress, it has builded high the bridges over the chasms that hindered his social advancement.

Thus do we answer the first part of our inquiry.

INTELLECTUAL DEVELOPMENT

We come now to the second part. Has engineering contributed to intellectual and moral development, has it bridged at higher levels the chasms that have held back man's spiritual progress?

Here our critics will rage. The age is decadent, they tell us; we are flabby intellectually, we have backslid morally. We have much information, they say, but little wisdom; alert perceptions, but little culture; athletic bodies, but no rigidity of moral character.

Are we able to answer the indictment?

There may not be a single luminary today of the brilliance of Shakespeare, or Dante, or Aristotle, but our age *is* one of striking intellectual vigor and activity.

If our galaxy has not a dominant luminary, it nevertheless has many great suns. In every line of human thought, the output of our researchers is prodigious. If an age is to be judged by the sum total of its contribution to human knowledge, then ours must be given high rank.

Each age, too, has its own *Zeitgeist*, the spirit of the age. Ours is science, pure and applied. In those fields we are making an intellectual contribution of stupendous proportions.

We claim, too, as an intellectual accomplishment the spread of education, common, secondary, and higher, to the masses of men in the Western world. To reclaim people from ignorance, to open to them the storehouses of knowledge and of wisdom, to make possible, yes, easy, for any one who wishes to secure it the very highest education, is indeed an accomplishment of which the machine age may justly be proud. That the education of the will has not gone along as lustily as the education of the intellect is a charge we will have to admit, but it does not completely negative the intellectual achievement.

MORAL CONDITION

But what of our moral life? Who shall judge it? Not I. There is no more difficult task for the historian than to determine the moral tone of an age—to strike the average from king to peasant, from president to humble citizen. In this respect no age can be sure of its appraisal of itself. The human soul—the millions of human souls of the Western world—cannot be weighed nor calipered.

Certainly we are not morally what we would like to

be or ought to be. That can be said of our intellectual stature as well.

But if our age has not risen to the intellectual and moral standard that we would wish, if we have not raised to top height the bridges over the chasms that handicap our intellectual and moral lives, the fault is not that of the engineer, but of the very teachers, religious leaders, economists, and statesmen who are today his critics. We find here another fundamental and elemental principle that should be stressed as strongly as the rapidity of wealth production. It is this: that the engineer has created an environment far more favorable to widespread intellectual and moral growth than the world hitherto has ever known.

Let that, in turn, be *our* challenge.

FAILURES OF OUR CRITICS

It is because the economist, the financier, the statesman, the teacher, the religious leader have not been able to keep pace with the engineer that untold difficulties arise. The more rapid creation of wealth has changed the whole base of Western civilization. It is the misunderstanding of this factor and the failure to recognize its profound and all-pervasive influence on finance, business, the distribution of wealth, national and international politics, and on human thought and outlook, that have thrown the Western world into its present crisis and baffled its statesmen.

But if these other groups have not been able to keep pace with the engineer, we should not be too critical. We have behind us 60 centuries of recorded history, in only two of which has modern engineering been a factor. In fact, Watt was a man of only yesterday. We can almost touch his times. He died in 1819, and the grandparents of many of us in this room might well have known him.

The machine age, then, has been operative for less than 3 per cent of recorded history. It is still a new instrument in the life of the race. We have not learned its mastery. We have not made it fully servant of the whole of mankind.

In the early days of steam engineering there were heaven-crying cruelties in its application. Strong hands seized the new wealth-creating mechanism and turned it to their own selfish ends. Engineering at that time, instead of bridging chasms, was used by greed to dig them deeper.

Later, as its benefits became more widely diffused, we used its gifts too lavishly. Our whole age, every one of us, is of the new rich in a large sense; and we used the new wealth—as the new rich always do—extravagantly, lavishly, even boisterously. We have not had the strength to resist the complexity and material temptations of the new wealth and patiently, calmly, taking advantage of the superior environment, let it work out in us a holy enlargement of intellect and soul.

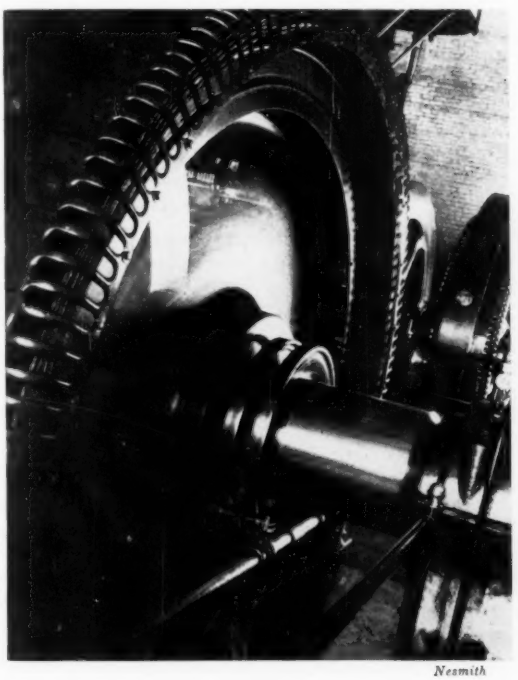
But be assured that we are mastering, we will master, the new instrument. Much of what has been going on in Washington in the last three months is an effort in this direction. The phrase "the forgotten man" is not a mere political catchword but the expression of a fundamental social philosophy.

Our contention, then, is that we engineers have not only builded higher bridges across the chasms, but we have furnished the materials for still higher bridges if the statesmen, economists, and teachers can learn to use them.

We believe that there has been a century of progress.

CONCLUSION

Solemnly tonight we look back on the arduous work of the race, struggling through 60 centuries or more in its effort to raise a high road over which to travel to its destiny—widespread happiness, with reasonable physical comfort, a high intellectual level, and a high moral order. In the nearly two centuries of steam power, engineering's record is not clean. In its early days, seized by greed, it tore down bridges instead of raising them. Latterly though, it has been made more and more the servant of the race, it has raised high the bridges over the chasms that impeded social progress; it has helped bridge the chasms of ignorance and moral turpitude by creating an environment far more favorable to intellectual and moral development than in the past.



Nesmith

It is in the faith that he was making a contribution to the race that the engineer has worked in the past 100 years, faith that he was bridging the chasms on the highway of mankind. In that faith will we and our successors carry forward in the century ahead so that when *its* history is written, it may more truly be set down as a century of progress.

In that faith will we work, not primarily that man may have greater comfort and more leisure, but that these may contribute to a more vigorous intellectual and a higher moral life.

"Not in bread alone doth man live but in every word that proceedeth from the mouth of God."

The CENTURY *of* PROGRESS —*What Next?*

By KARL T. COMPTON[1]

THE CONSUMMATION of the plans for A Century of Progress Exposition, carried out in the very depths of the worst economic depression of recent history, deserves to be classed with the "seven wonders of the world." Beneath and back of its bewildering display of the principles and applications of science, to the accompaniment of amusement and modernistic art, and back of the evident desire of some millions of people to spend time and money to visit this exposition, there certainly lies something significant.

EDUCATIONAL SIGNIFICANCE OF THE EXPOSITION

The exposition will have a far-reaching effect on education. Those of us who have specialized in science or practised engineering have some understanding of what science has done to our life and environment, but the average citizen takes most of these new things more or less as a matter of course. Hundreds of thousands of thoughtful people, who have believed themselves reasonably well educated, are going to receive a mental shock when they see, spread out before them, hundreds of things which affect their lives most intimately but which they do not understand and never before realized. Therefore, I believe that this exposition will increase interest in and demand for education in pure and applied science.

I venture to assert that no other branch of learning can compare with science in its educational value. It is the best of all disciplines, since it requires logical, straightforward thinking in which all conclusions can be checked. Bluff, loose thinking, and dishonesty can get nowhere in science. It offers scope for the imagination, limited only by the truth. It has such obvious utilitarian value that this point need not be discussed further. It develops an appreciation of a real art whose basis lies in simplicity, neatness, and adequacy of relationships and forms. But perhaps it is not always realized that it is the most cultural of all studies.

I like to define culture as "the sympathetic appreciation and understanding of life." Our understanding of life rests on science. Before there was science, man was a superstitious, ineffective person, afraid of his environment and dominated in his thinking by misconceptions in which he played either a ludicrously self-important or else a fatalistically negligible rôle. With science have come some understanding of life and its environment and some control of this environment. With this control, man has gained free time for thought and new material about which to think. Of course I do not mean that culture is *all* science, but I do mean that pure and applied science are far more basic elements in culture than is generally realized.

The point of view on these matters has changed rapidly in recent years. This exposition will accelerate that change. Science and technology will play an increasingly important part in our educational system.

WHAT NEXT?

Prophecy at best is a dangerous pastime, but a certain amount of it is necessary in order to plan intelligently for the future. All of you have probably heard the "wise crack" at the Weather Bureau made by some congressmen who suggested, as an economy measure, that the entire service be discontinued except for one man whose sole duty it should be to predict fair weather every day. By so doing, he would be right seventy-five per cent of the time, which is better than the present average. (I can't vouch for the accuracy of these figures, nor do I subscribe to the proposed solution. On the contrary, I would point out the great advantages of introducing a still more extensive system than we now have, along the lines of the Norwegian system of Bjerknes, which adds upper-air soundings to the present type of observations and which has been studied, practised, and advocated in this country by the Massachusetts Institute of Technology and the California Institute of Technology.)

Also, the economic forecasters have taken a beating in recent years. In fact, one of the leading critical statisticians of this country told me that, with all the theory and talent engaged in business forecasting bureaus, their average of success was markedly worse than the results which would have been obtained by flipping a coin.

In spite of many failures of prediction, however, we recognize the fact that we must continue to predict as best we can in order to plan our course intelligently. And we realize that the shortcomings of our present efforts are due to faulty technique, arising from inadequate information or imperfect logic, and that we must strive to improve this technique.

THE LESSON OF THE SECOND LAW OF THERMODYNAMICS

The Second Law of Thermodynamics is an exceedingly potent principle in science and engineering. From it I would draw a lesson for the future. It may be stated in a variety of ways, one of which is that any system, if left to itself, tends to the state of maximum disorganiza-

[1] President, Massachusetts Institute of Technology, Cambridge, Mass.

An address delivered at the joint banquet of all engineering societies participating in Engineering Week at A Century of Progress Exposition, Chicago, Ill., June 28, 1933. Abridged.

tion. Consider the simplest physical case, that of a gas. However its molecules may initially be arranged as to positions and energies, it tends to take on a completely random configuration, in which the energy which it contains is not available. The only scheme ever proposed for breaking up this randomness and making the energy available is Maxwell's hypothetical demon, who operates as follows: Imagine, for example, that this room is divided into two parts by an insulating partition provided with a single opening only large enough for a molecule to pass through, and that this opening is provided with a trap door, operated by the demon. Whenever this demon sees a fast molecule coming toward the door from the left, he opens it just long enough to let the molecule through. Similarly, he lets slowly moving molecules go through from the right. Thus he sorts out the molecules, ultimately corralling the fast ones in the right and the slow ones in the left chamber. In this way, he sets up a difference in temperature between the two chambers and is then able to get work done by the gas whose energy originally was unavailable. He does this by exercising his intelligence in the selection of molecules passing through the trap door.

By analogy with this, I would venture the assertion that it is only by the exercise of intelligence that we can avoid the condition of maximum disorganization. Examples of this in human affairs are numerous. Consider, for example, what happens to a farm when it is abandoned. It grows up in weeds, briars, and brush. Consider what would happen in the construction of a building, or of A Century of Progress Exposition, if it were carried on without intelligent planning and direction. Consider what happens in business if it is carried on without intelligent correlation of production, distribution, and sales. Consider what happens in public-works construction if this is carried on by the whim of legislatures or temporary officials without an intelligent, coordinated plan of present and future development. Consider what happens in international affairs if each nation, like a gas molecule, "bats" around intent on its own affairs without reference to its coordination with the actions of others in a well-planned, concerted program for the ultimate benefit of all.

So the Second Law of Thermodynamics may be taken to symbolize the necessity of intelligent planning and consistent adherence to the plan if confusion and disorganization are to be avoided. But if men are to work together effectively, there is another point to be considered, which also may be suggested by a scientific analogy, this time from the field of chemistry.

LOSING IN FREEDOM AND GAINING IN POWERS

Every chemical bond indicates the loss of a degree of freedom. An atom of hydrogen has three degrees of freedom, those of translation in three mutually perpendicular directions. Similarly, an atom of chlorine has three degrees of freedom. But when these two atoms combine to form a molecule of hydrochloric acid, one degree of freedom is lost and there remain only five, three of translation and two of rotation. But in exchange for this partial loss of freedom, there are gained new properties and powers which did not reside in the individual atoms themselves.

Similarly, in society, every social, political, or legal bond represents a certain loss of individual freedom, but through this loss we gain new powers and opportunities. The extreme individualist, who resents any constraint, loses thereby the advantages of cooperation and becomes like a molecule, senselessly batted around by all the contacts which he cannot escape.

Modern engineering developments have created new and tremendous bonds between people. Transportation, communication, modern methods of production—all these major items of progress which are exhibited at this Century of Progress, have the effect of making people more interdependent. They are interdependent for food, clothing, education, ideas, and, in fact, in practically all their activities. They have thereby lost many of their individual degrees of freedom, but have gained tremendous new powers and opportunities.

This, I believe, is by far the most significant feature of the Century of Progress. It is a feature which is as yet inadequately realized. Many individuals, and industrial groups, and nations are still trying to live like free atoms when they are really parts of a great organism. Failure to realize this results in strains which sometimes develop into cracks. I take it that the great problem of mankind is to learn how to surrender antiquated degrees of freedom and how best to use the new powers and opportunities which come from cooperation. Since the engineers have largely created this problem, it is largely up to them to lead in its solution. I could quote many examples to show that they are beginning to do so.

SIGNIFICANCE OF EVOLUTION OF SOCIAL PHILOSOPHIES

Let me now approach the question, "What Next?" from still another angle. I once heard a quotation from a Greek philosopher which went something like this: "It is not by sacrifices or the mysterious power of the oracle that we may look into the future, but by giving thought to the past, which we know." Let us draw certain lessons from the past.

The evolution of social philosophies is significant. In earliest times, life was entirely individualistic, each family being a law unto itself. Later, as population increased and concentrated, there came a period of autocracy in which an individual, or a group, ruled by force of might over the subjugated peoples. With the French and American revolutions came the period of democracy in which the rights of the individual were supreme, in sharp contrast to the preceding order. In America, with its almost boundless resources and opportunities for individual enterprise, this developed into an extreme individualism. As the country's resources became more completely exploited and the population increased, there developed a period of intense competition—free, cutthroat, and individualistic. Really as a part of this competition came gigantic combinations, trusts, whose abuse of power led to overdrastic governmental control. We have recently suffered and still suffer from

this mixture of unrestricted competition and unwisely restricted combination. What is the way out? It must be by some form of cooperation in which the interests of the public will be paramount, but which will still leave room and incentive for individual enterprise without which future progress would be suppressed.

THE SIGNIFICANCE OF INDUSTRIAL RESEARCH

The trends in industrial activity are also significant. In the general period of the Civil War, our great railroads, which form the backbone of our transportation system, were the outstanding achievement of the time. Then came a period of development of machine tools and their employment in manufacturing and farming to give what we call mass or quantity production. Finally, since 1910, has come industrial research on an increasingly important scale. This research has been directed toward new products, such as the automobile, radio, airplane, mineral and oil products, food and medicines, and also to the invention of new materials for construction, such as plastics, stainless and hardened steels, rayon, and the like. Still more recently, research into and control of business and personnel management and production have appeared on the horizon.

A survey made by the Division of Engineering and Industrial Research of the National Research Council, two or three years ago, showed strikingly the fact that the most prosperous industries are those which spend considerable funds in research. There are many illustrations which might be cited. For example, the electrical and chemical industries, founded upon and maintained by research, have prospered.

Continual research and alertness to give public service are the essential conditions for success, and even for survival, in this age of technology and of social interdependence.

THE FUTURE DEMANDS INTELLIGENT PLANNING

You will have noted that, from every angle of approach, the survey of recent progress leads to a definite conclusion: We are entering an age in which the conditions for success will be intelligent planning, based on research, and general cooperation in such a planned economy. Research and cooperation are the key ideas. Engineers have a unique opportunity in this program, since their work is constructive in exactly the lines in which lie the greatest problems. It is no mere chance that the "strong-arm" man of the administration, Director of the Budget Lewis Douglas, is an engineer, or that the first three men chosen to advise in the administration of the Industrial Recovery Act, Gerard Swope, A. P. Sloan, and Walter Teagle, are all engineers, or that Colonel Sawyer in charge of the Federal public-works program is an engineer, or even that our ex-president, who struggled manfully against overwhelming odds, was an engineer.

Ewing Galloway

AVENUE OF FLAGS, CHICAGO EXPOSITION

CONCLUSION

In conclusion, let me set forth a few specific predictions based on the considerations I have already cited, as follows:

(1) Research in pure science, engineering, and social science will receive increasingly greater attention, and ways will be found to make it more effective.

(2) Society will exercise increasing control over business and industry to insure that the best interests of the public are to be served. This will inevitably include measures for stabilization of employment, control of production, and safeguarding of investments.

(3) Technological education will be increasingly recognized as a most valuable preparation for a satisfactory life in this technological world, as well as the *necessary* training for that large special group who themselves develop, build, and operate the world's machinery.

(4) Because of the engineer's responsibility, it is important that he have a more adequate sense of social responsibility and training to discharge humanitarian as well as technical responsibilities effectively, and these requirements will be reflected in modifications in the present methods of his college training.

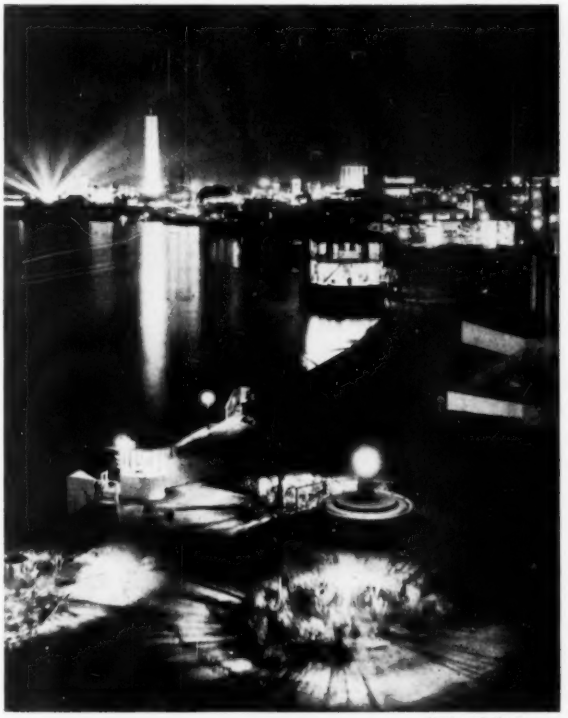
And so I might list a great variety of details. But they all sum up into three conclusions: There is a tremendously important job to be done in the world, a job which has arisen in large part because of the work of the engineer. The engineers of the present and future have a tremendous opportunity and responsibility for doing this job. If they do not do it, then we may expect great confusion, as would be predicted from the principle of the Second Law of Thermodynamics.

I think, however, that there is every reason for optimism. There are plenty of interesting things to be done in the world. This Century of Progress Exposition has concentrated attention on many of them and created a psychology of satisfaction, optimism, and ambition. We should view the future seriously, but we have reason to look forward confidently.

The A.S.M.E. *at* CHICAGO

An Account of Technical Meetings and Society Affairs During Engineering Week, June 25 to July 1, 1933

A VARIETY of impressions will make the 1933 Semi-Annual Meeting of The American Society of Mechanical Engineers, held at the Palmer House, Chicago, Ill., during Engineering Week, June 25 to July 1, with a registration of 1357 members and guests, an occasion long to be remembered. For example, there are those who traveled to Chicago for the first time on an air-conditioned train, who will contrast the comfort of that journey with the heat of the week that followed. Others will recall that Engineering Week provided the first instance in thirteen years, and the second in their history, that the four Founder Societies met simultaneously, and that their governing bodies and that of the United Engineering Trustees came together for a joint meeting. The extensive technical program will be remembered by many who tried to absorb a maximum of discussion of engineering papers, for in all there were more than a dozen engineering societies in session during the week. Certain perplexed representatives of various industries will date from the Chicago Meeting the impact of the "new deal" on their several trade associations and will have memories of the confusion and difficulties attending the setting up of codes of fair practice. But these, and numerous other impressions, will probably be overshadowed, as time goes on, by the realization that it was A Century of Progress Exposition that concentrated so many activities in Chicago.



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CHICAGO EXPOSITION AT NIGHT

I—A.S.M.E. COUNCIL MEETING

In so far as The American Society of Mechanical Engineers was concerned, Sunday, June 25, marked the beginning of Engineering Week. Following a morning meeting of its Executive Committee, the Council of the Society and representatives of the standing committees lunched together informally as a prelude to the meeting of Council. Luncheon having been served, A. A. Potter, president of the Society, reported to the Council the activities of its Executive Committee which had held five regular and one special session, in addition to that of June 25, since the December meeting of the Council. Every one of these meetings the president had attended.

President Potter reported that since taking office in December, 1932, he had been privileged to visit 36 local sections, 33 student branches, and 3 regional student conferences. In connection with these visits, he had addressed at least 10,000 persons, including 4000 Society members and 6000 engineering students. His visits had impressed him, he said, with the high quality of the Society's members, and with their deep interest in the welfare and prestige of the Society. He had, of course, heard criticisms of the Society and of the management of its affairs, and these he had faithfully transmitted to the Executive Committee and to the Special Committee on Policies and Budget.

FISCAL PROBLEMS

The Executive Committee, President Potter reported, had devoted much time in attempting to anticipate the problems of the immediate future, and particularly those arising out of decreased income from advertising and members' dues. He recalled to members of Council that the discussion of dues reduction and problems of financing had led to the calling into active service of the Special Committee on Revenues, later reorganized as the Special Committee on Policies and Budget, under the chairmanship of Harry R. Westcott, of New Haven. This report was a subject of discussion later in the meeting.

On January 12, 1933, President Potter said, a reduction in the budget of $74,000 had to be made, and with subsequent falling off of income, it had become obvious to the Finance Committee, at its meeting of June 20, that the Society would face a deficit for the year. These facts demonstrated the importance of giving careful consideration to the report of the Special Committee on Policies and Budget, and to the proposed Budget for 1933–34, which was being reported.

Reductions in interest rates on investments legal for trust funds held by the Society and the banking holiday of last March had seriously affected the Society's cash position, said President Potter. Assisting in overcoming this handicap, he was happy to announce, had been funds amounting to $1615 from 145 members in good standing who made contributions in excess of their dues, and $1060 from 56 dues-exempt members who considered the present emergency an opportunity to be of financial assistance.

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ALONG CHICAGO'S MICHIGAN AVENUE

Relief of unemployment had also been given consideration by the Executive Committee and by the Society's special Committee on Unemployment, said President Potter. From a study of the unemployment situation in 20 local sections, it was discovered that eight were doing nothing, and that twelve were very active, eleven working jointly with other engineering groups.

MISCELLANEOUS PROBLEMS

Other points touched on by President Potter were the increasing activity of Junior members in Society work, the need for attracting distinguished engineers and engineering executives to the Society, the work of the Coordinating Committee appointed by the Founder Societies and the United Engineering Trustees, participation by the Society in the Engineers' Council for Professional Development, and such economies as were represented by the abandonment of preprints of papers and by the suspension of the *A.S.M.E. News*.

He reminded members of Council of the serious problems with which they were faced, and expressed his opinion that the Society was in a strong position professionally. "As members of Council," he said, "we have the real responsibility of bringing forward our Society on a high plane of usefulness and prestige during the period of emergency which we face." He concluded with a gracious tribute to the members of the Executive Committee and the staff for their cooperation and encouragement.

BUDGET POLICY

Consideration of the 1933–34 budget which followed President Potter's report, was preceded by a discussion, with ultimate approval except for brief changes in wording, of certain recommended policies that had been taken from the report of the Special Committee on Policies and Budget. The high points of these recommendations are as follows:

That there be no reductions in rates of dues but that an opportunity be provided for quarterly payment, and that further efforts be made to impress on members the necessity of paying their dues.

That during 1933–34 no new local sections be organized and that inactive sections be temporarily suspended; that there be decreased appropriations to larger and increased appropriations to smaller sections; and that appropriations to local sections for the second half of the year be on the basis of the number of members whose current dues are paid.

That the Transactions be distributed gratis on the basis of only two sections per member, and that preprints for meetings be not prepared during 1933–34.

That there be a temporary curtailment in the work of certain committees.

That the *Engineering Index* be suspended on January 1, 1934, unless some agency can be found before that time to finance it.

Other recommendations related to numerous details of operation and to the general program of economy.

The budget for 1933–34, as reported by the Finance Committee, was adopted.

CHANGES IN BY-LAWS AND RULES

The Committee on Constitution and By-Laws presented amendments to the By-Laws and Rules, which were accepted by the Council. Amendment to Article B8, Par. 36, related to the selection of delegates to the American Engineering Council, making it uniform with the procedure of other societies and with the procedure of the A.S.M.E. in the appointment of representatives on other joint bodies.

The additions of a new paragraph (7) to Article B11, recognized the existence of the Annual Conference of Local Sections Delegates, and Article R11, Rule 8, was amended to read as follows: "Each Local Section shall have the privilege of representation at the Annual Meeting of the Society by one official delegate. It shall be the duty of such delegate to attend the Business Sessions of the Annual Meeting. Such delegate, the chairman if possible, may have such portion of his expenses for transportation to the meeting refunded by the Society as the Committee on Local Sections may direct."

Two amendments were presented for first reading: Article B15, Par. 1, was amended by the substitution of the new Code of Ethics, approved by Council, December 5, 1932; and Article B5, Par. 9, relating to life membership, was amended to give proper consideration to the fact that a member is exempt from payment of dues when his membership has extended over a period of 35 years.

RECOMMENDATIONS OF COMMITTEE ON LOCAL SECTIONS

Acting upon one of the suggestions of the Committee on Policies and Budget, the Council voted, on the recommendation of the Committee on Local Sections, to approve the temporary suspension of the following Local Sections: Charlotte, Florida, Green-Mountain, Greenville, Inland Empire, Memphis, Meriden, New Britain, Pittsburgh, Savannah, Utica, Virginia, West Virginia, and Youngstown.

Upon the recommendation of the Committee on Local Sections, it was voted to approve the holding, during the fall of 1933, of regional degelates conferences in convenient locations.

Under the plan adopted, each of these groups will select one delegate to attend the 1933 Annual Conference in New York, to meet with members of Council and representatives of professional divisions and standing and special committees, and each group will make its nominations for the Nominating

Committee. It is also planned that one member of the Committee on Local Sections and that the members of Council residing within these groups shall attend these conferences, if possible.

It was voted that the payment of initiation fees by student members becoming junior members be extended to January 1, 1934.

DINNER MEETING OF THE COUNCIL

The Council meeting was followed by a dinner attended by members of Council and of the Society's standing and special committees, at which H. R. Westcott, chairman of the Special Committee on Policies and Budget, spoke on "The Aims and Objectives of the Society;" C. F. Hirshfeld, chairman pro tempore of the Engineers' Council for Professional Development, spoke on "The Society and the Development of the Profession;" and W. L. Batt, chairman, Coordination Committee, United Engineering Trustees, Inc., spoke on "The Society and the Profession."

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WACKER DRIVE AND THE CHICAGO RIVER

II—THE TECHNICAL SESSIONS

While numerous activities of the other engineering societies meeting in Chicago, the attraction of the Exposition, and various other duties and pleasures, offered severe competition, nevertheless, the technical sessions of the A.S.M.E. Semi-Annual Meeting were well attended and discussion on the whole was lively and profitable.

The program provided 44 sessions over a period of five days, during which 126 papers were presented and discussed. In addition to this, numerous meetings of technical and executive committees were held.

No attempt can be made to summarize here even briefly the technical papers and the discussion they provoked. As an economy measure, preprints of papers, except in a few cases where special provision had been made by the authors or others, were not available, except in abstract form. To make up for this deficiency, a special publication had been prepared, containing a detailed program of technical and non-technical events and abstracts, of approximately 1000 words each, of every paper. Every member and guest was provided with a copy of this publication upon registration.

JOINT SESSIONS A FEATURE

A notable feature of the technical program was the great number of sessions sponsored jointly by two or more of the engineering societies meeting during Engineering Week in Chicago. The American Society of Civil Engineers, for example, joined with the A.S.M.E. divisions of Applied Mechanics and Hydraulics in several sessions, as did the American Foundrymen's Association with the A.S.M.E. Machine Shop Practice Division, while under the auspices of the Econometric Society, the A.S.M.E., the A.I.E.E., and the A.S.T.M. met jointly to discuss five papers that have been abstracted elsewhere in this issue. At the Stevens Hotel, the A.S.M.E. Materials Handling Division cooperated with the American Foundrymen's Association. Members of the A.S.M.E., the A.S.C.E., and the Society of American Military Engineers lunched together on Thursday. On Tuesday evening, Section M of the A.A.A.S. joined with the engineering societies present in Chicago to listen to a lecture on "Industrial Developments of a Century," delivered by Dr. A. P. M. Fleming, Manager of Research and Education Department, Metropolitan-Vickers Electrical Co., Manchester, England.

It is to be hoped that many of the very excellent papers presented at Chicago may subsequently be published, with discussion, in the A.S.M.E. Transactions so that they may be available for study and reference. Some of them have already been generously treated in several trade and professional periodicals.

III—INDUSTRIAL DEVELOPMENTS OF A CENTURY

Into the brief space of time that was allotted to him on Tuesday evening, Dr. A. P. M. Fleming crowded a comprehensive account of the industrial developments of the century, following an introduction by Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology, who acted as chairman of the joint session under the auspices of Section M (Engineering) of the American Association for the Advancement of Science.

Dr. Fleming showed that it would be impossible today to maintain the populations of the world at their present standard of living if the transformation of Nature's resources into finished products depended solely on manual effort. The power necessary for this purpose and for the distribution of the products, he said, had been made available by engineering, in which science had been the creative faculty.

After a brief survey of the world's industrial position in 1833, Dr. Fleming gave a comprehensive survey of the development of power, and of the men and their contributions that had made this development possible. His survey included prime movers, by which energy in some form was converted into mechanical energy; generators, by which mechanical energy could be converted into electrical form; the transmission and distribution of electrical power; and the uses of power.

Turning next to other contemporary developments, Dr. Fleming spoke of the progress that had been made in ferrous and non-ferrous metallurgy and in the chemical industries

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THE GENERAL MOTORS ASSEMBLY PLANT AT THE EXPOSITION

during the century. He then showed the importance and the influence of tools, measurements, and standards, and gave a brief résumé of progress in research and industrial organization.

PROGRESS DEPENDS ON ENGINEERING

At the conclusion of his address, Dr. Fleming said that the developments of the past century had showed that the magnitude and rate of progress had depended on engineering. Through the growth and application of scientific knowledge, the world had become a small place; travel by road, rail, air, and water had increased in speed; communication had eliminated time and distance; the earth's resources had been made universally available; and means had been provided for the growth and maintenance of populations with increasing standards of living. In other directions, medical science and education had made impressive advances.

It was sometimes said, he continued, that human nature could not control the machines that science and invention had produced and that this was largely responsible for the present state of world derangement. It was true that because of the creative impulses of war, facilities for production had attained a century's advance within a few years and that exchange and distribution had not kept pace with this abnormal growth. But surely this was a problem of organization only, and should not be beyond human intelligence to solve.

There were certain features in the trend of affairs that should give us cause for confidence, he concluded. Throughout the past century, material progress—the rapid development of wealth and its acquisition by a few—had seemed to matter most. Today, there was a tendency, which the economic stress had served to emphasize, to regard industry as a service, as a means to an end, the end being the greater development of intellectual life and higher ethical standards. Surely, it was the responsibility of engineers, scientists, and industrialists to foster this spirit.

IV—JOINT MEETING OF GOVERNING BODIES OF THE FOUNDER SOCIETIES AND UNITED ENGINEERING TRUSTEES, INC.

The governing bodies of the Founder Societies, and their presidents, met for dinner at the Palmer House, Tuesday, June 27, to hear and discuss statements about some of their joint activities, made by William L. Batt, chairman of the Coordination Committee of Engineering Societies. United Engineering Trustees joined in the meeting, and chairmen of the subcommittees of the Coordination Committee were present by invitation, together with a few other guests. The total attendance was 56.

Harold V. Coes, president of United Engineering Trustees, presided. Mr. Batt explained the committee's report of May 1, 1933, outlined some of the committee's investigations and discussions, and emphasized the mutuality of the relations between the societies and their joint organizations.

F. M. Becket, president of the A.I.M.E., speaking on research, commended the breadth, variety, and quality of the work done by The Engineering Foundation, but suggested that henceforth greater attention be devoted to the humanitarian aspects of engineering research. Especially he spoke of Engineering Societies Library as one of the most needed and helpful aids to engineering research, and bespoke for it substantial aid from the Foundation.

A. J. Hammond, president of the A.S.C.E., spoke on the Joint Advisory Board proposed by the Coordination Committee. He endorsed this proposal heartily, and suggested that United Engineering Trustees, Inc., might well be the nucleus.

H. P. Charlesworth, president of the A.I.E.E., also spoke enthusiastically on the Engineering Societies Library and the relations of the Founder Societies thereto. He gave many interesting facts about the variety, value, and geographical scope of the library's services. Particularly, he spoke of the increased use of the library in "the depression," and its special helpfulness to unemployed members of the societies. He, too, urged large increase of the library's resources.

A. A. Potter, president of the A.S.M.E., spoke of the great value of high professional standards, of the need for better engineering education, and of the necessity for effective united interest of the engineering societies. As a means to these ends he outlined the purposes of the Engineers' Council for Professional Development.

Mr. Coes read a telegram from Dr. Ambrose Swasey regretting that the heat prevented his presence in Chicago at this time. By direction of the meeting, a telegram of appreciation and good wishes was dispatched to Dr. Swasey.

As a result of a previous understanding, no action was taken at this meeting, but it was an occasion of inspiration and pleasure and promotion of acquaintanceship. There has been no similar meeting since the one on January 23, 1920, arranged by the "old" Engineering Council.

V—ENGINEERS' DAY PROGRAM

With the meeting in Chicago simultaneously of more than a dozen engineering societies, Wednesday, June 28, was designated Engineers' Day at A Century of Progress Exposition. The formal exercises were held in Soldier Field Stadium during the morning and centered around the presentation of the Daniel Guggenheim Medal to Juan de la Cierva. The remainder of the day was spent in individual inspection of the Exposition.

PRESENTATION OF THE DANIEL GUGGENHEIM MEDAL TO JUAN DE LA CIERVA

Before a large audience in Soldier Field Stadium the 1932 medal and certificate were presented to Juan de la Cierva "for

development of the theory and practise of the autogiro." The ceremony began with a military drill, followed by an address of welcome to the engineering societies by Harry B. Gear, chairman of the Chicago Engineers Committee. The medalist, Harold F. Pitcairn, president of the Pitcairn Autogiro Company, of Philadelphia, and James G. Ray, pilot, landed in an autogiro before the speakers' stand, having flown from Philadelphia to Chicago the preceding day.

The medalist's party was received by A. A. Potter, president of The American Society of Mechanical Engineers, who presided and made the following statement about the medal:

"Progress has always been dependent upon persons who had courage and vision to explore the unknown, and upon those who made life easier and happier through inventions and discoveries.

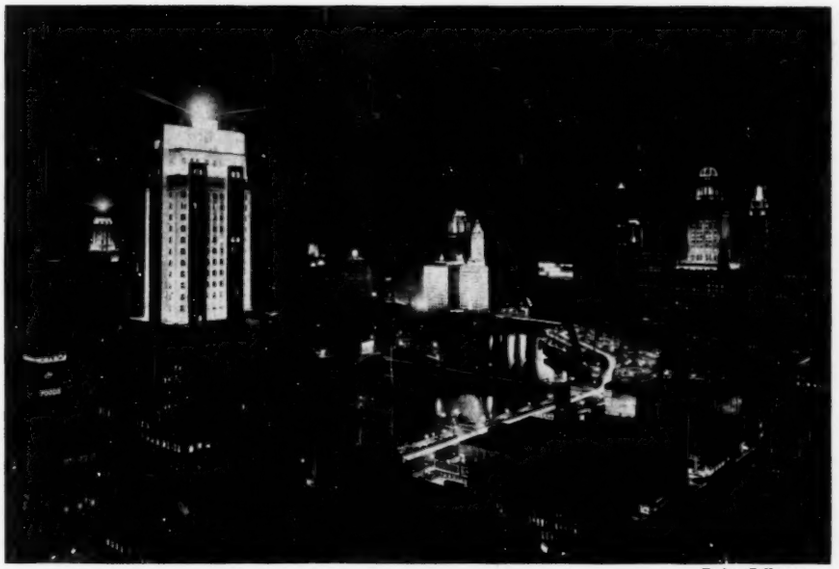
"The Daniel Guggenheim Medal, which is to be presented today to a distinguished inventor, was created for the purpose of honoring persons who make notable achievements in the advancement of aeronautics; it is also in commemoration of the encouragement given by Daniel Guggenheim to civil aviation and to the schools of aeronautics.

"The Daniel Guggenheim Medal is being administered by a Board of Award made up of four directors from The American Society of Mechanical Engineers, four directors from the Society of Automotive Engineers, and also representatives from Canada, England, France, Germany, Holland, Italy, and Japan, each designated by the leading aeronautical organization in his country. The chairman of the Board of Award is Edwin E. Aldrin, and the secretary, Alfred D. Flinn.

"This Guggenheim Medal has previously been awarded to Orville Wright, of the United States of America, to Ludwig Prandtl, of Germany, and to Frederick William Lanchester, of England. For 1932, a distinguished Spanish engineer was nominated to receive the award.

"It is most fitting that on this important occasion the medalist should be introduced by one, who, as an inventor, a builder, and a flier of airplanes, and as a director of large and important industries, has played a leading rôle in the development of aeronautics in this country. It is my privilege to present to you Harold Frederick Pitcairn, a holder of the John Scott Medal for his ingenuity and inventive ability, who has kindly consented to introduce our guest of honor."

Mr. Pitcairn gave a short biography of the medalist, particularly his achievements which led to the award. Then Edwin E. Aldrin, chairman of the Board of Award, presented the medal and certificate, repeating the citation. The medalist responded, and after the ceremony, reviewed a parade of a battalion of the United States Army and a post of the American Legion. After a reception by Dr. Cierva, the autogiro left the stadium. The ceremony was broadcast over a national network.



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CHICAGO SKYLINE AT NIGHT

ENGINEERS' DAY DINNER

The climax of Engineers' Day was a joint banquet participated in by all of the engineering societies and their guests, and held at the Stevens Hotel. At the speakers' table were the presidents of these societies, a representative of the Mayor of Chicago, and distinguished guests. Elsewhere in this issue will be found in abridged form the addresses delivered by Edward J. Mehren and Karl T. Compton at this dinner.

VI—HENRY S. DENNISON AWARDED GANTT MEDAL

One of the pleasantly remembered events of the Chicago meeting was the award, to Henry S. Dennison, president, Dennison Manufacturing Company, of the Gantt Medal, established in 1930 in memory of Henry Laurence Gantt, pioneer in management engineering.

The award was made by a committee of six: Joseph W. Roe of New York University, chairman, J. P. Jordan (deceased), and Harold V. Coes, of Ford, Bacon and Davis, Inc., New York, representing the Institute of Management; and Dexter S. Kimball, of Cornell University, R. A. Wentworth, of New York, and John W. Nickerson, Cheney Brothers, South Manchester, Conn., representing The American Society of Mechanical Engineers. The medal was awarded "for distinguished achievement in industrial management as a service to the community." E. O. Griffenhagen, senior partner, Griffenhagen Associates, management engineers, of Chicago, made the presentation address.

In accepting the medal, Mr. Dennison said that he did so as a tribute to Henry Laurence Gantt, who foresaw the need for national planning when management was in the early stages of its development and had not progressed beyond application to the workshop and factory. Mr. Gantt had realized, said Mr. Dennison, that on management lay the responsibility of unemployment, and that management fell short of fulfilment if it did not take account of the human factor and the consequences to humanity of industrial evolution. Management, he continued, knew no lines of distinction between the political and business world. In his opinion, a system of disorganized production was suicidal. It was necessary for management to come out of its hole and to realize that it must cover the entire field in which it was applicable. With an increasingly closer partnership between government and business, he said, there would come a need for a higher grade of management.

The Gantt Medal was first awarded, in 1930, posthumously, to Henry Laurence Gantt. The second award was made to Fred J. Miller, and that of last year to Leon P. Alford.

ECONOMETRICS *and* ENGINEERING

Résumé of Papers and Discussions Presented at Chicago

TWO SIGNIFICANT SESSIONS on econometrics and engineering were staged on June 29 during Engineering Week at A Century of Progress Exposition under the auspices of the Econometric Society and the joint co-sponsorship of the A.S.M.E., the A.I.E.E., and the A.S.T.M. The general program was arranged under the direction of Dr. W. A. Shewhart, of the Bell Telephone Laboratories, whose writings on the engineering applications of probability are well known, and whose work on the theory of quality control of manufactured articles has brought him to the favorable attention of engineers interested in production.

The afternoon session, at which the engineering profession was represented by a paper by Dean Dexter S. Kimball, printed elsewhere in this issue, and the econometricians by Dr. Charles F. Roos, secretary of the Econometric Society, and Dr. Thornton C. Fry, Mathematical Research Engineer of the Bell Telephone Laboratories, was under the able chairmanship of Dr. Irving Fisher, of Yale University, president of the Econometric Society, distinguished economist, and contributor to the mathematical study of economics. At the evening session, the presiding officer was Ralph E. Flanders, member A.S.M.E., chairman of the Committee on Economic Balance of the American Engineering Council, and recently appointed by Secretary Roper on the Advisory and Long Range Planning Committee of the Industrial Recovery Administration; and the papers were presented by Dr. F. B. Jewett, vice-president, American Telephone and Telegraph Co., and A. P. M. Fleming, Manager of Research and Education Department, Metropolitan-Vickers Electrical Co., Manchester, England, member of the A.S.M.E.

The large attendance at both sessions, in spite of the excessive heat, demonstrated the very real interest among engineers in the subjects under discussion, an interest which, as one discussor put it, arose from the fact that "both engineering and economics must deal with the problem of how to combine limited resources to achieve a given end, and must consequently make use of the principle of economy." This same principle of economy must govern the report of these econometric sessions, and the complete papers will not be incorporated in the following account. An attempt has been made, however, to outline their substance, and it is hoped that more complete treatment may be accorded some of them later, in this or in other journals.

I—CONTRIBUTIONS OF THE MATHEMATICIAN TO ECONOMICS

"The Contributions of the Mathematician to Economics" was the title of the paper presented by Dr. Charles Frederick Roos, secretary of the Econometric Society. He said, in part:

First of all, a study of economics is a study of changing relationships. Even the layman is now familiar with the fact that prices, production rates, taxes, etc., rise and fall. Stock prices may soar to two hundred dollars per share and then suddenly drop to ten or twenty dollars per share. Similarly, the price of real estate may oscillate, but usually not as violently as other prices. There are, therefore, changes in the relationships of economic factors to one another. It would seem, therefore, that a useful economic theory must be one that can predict within limits how changes in one or more elements will affect other elements. In the words of Vilfredo Pareto: "If we set up hypotheses that seem to fit concrete situations and allow certain elements to vary, the process of determining the effects of these variations on other elements leads to a development of economic theory."

Whenever one desires to state his hypotheses so clearly that he will not be misunderstood, he chooses his language very carefully. In order to reach valid conclusions, he makes certain that his hypotheses are self-consistent and that all possible variations are taken into account. Since mathematics is universally recognized as the language of hypotheses and variations—an exact language and a science of variation—it would seem that even a novice might expect mathematics to be useful in the development of economic theory.

THE ENGINEERING ANALOGY

Suppose that an engineer desired to design a shaft to carry a load of, say, ten tons. He would probably begin by assuming the modulus of rupture of the material selected to be approximately the same as the average experimental modulus of rupture of similar material. By means of mathematics familiar to engineers, he would then be able to calculate the dimension of the shaft. However, he would use a shaft of larger dimension to allow for a factor of safety—his material might not be as strong as the average material and the load might get slightly above ten tons, and so forth.

As an entirely analogous problem, one could propose to determine what the price of a piece of machinery should be in order that one thousand (or one million) units would sell within a year after production, but some one would almost surely ask how changes in advertising and sales activity, tariffs, currency changes, and taxes would be taken into account. The obvious reply is that when an engineer calculates the size of a shaft to carry a specified load, he assumes that the bearings will be properly oiled and that no sand or grit will be thrown into them. If he allows the bearings to heat excessively or to be subject to undue wear, he recognizes that he has complicated the problem. Similarly, a mathematical economist recognizes that the problem of calculating demand, when advertising, sales activity, and other things vary, is more complicated than the one for which these are assumed to be constant. In order to solve the complicated problem, the mathematical economist will, of course, need to know the laws of variation of price and demand with advertising outlay, etc.

VARIABILITY OF HUMAN BEHAVIOR NO ARGUMENT

Some economists and others have said that there are so many variables involved in a study of human behavior that it will never be possible to develop a science of economics. To those who would use this as an argument for not using mathematics in economics, one might reply that, because there are so many

variables, there is all the more need for an exact language to keep track of them. No one would advise an astronomer to develop a science of the stars without using mathematics. There is, of course, a very great difference between astronomy and economics. The astronomer knows the laws of motion of individual bodies under the influences of forces, whereas the economist does not know the laws of human behavior.

Individuals seem to react so differently to situations that it may never be possible to predict how a given individual will react to a particular situation. For example, in the consummation of a sale, such elusive factors as the personality of the salesman, individual prejudices, misinformation, or, perhaps more often, lack of information, play such important rôles that it may never be possible to determine the demand of any particular individual for a given product.

Although individuals often appear to react capriciously, nevertheless, for a large enough group there ought to be what might be called an average salesman and an average purchaser. These average individuals might be expected to react almost identically to identical situations, for, otherwise, there could be no norm of rationality. Thus, Prof. Ragnar Frisch, in his book on measuring marginal utility, postulates an average person by using data relating to a group to measure the flexibility of the marginal utility of money. Again, although it may not be possible to predict how many telephone calls John Smith will make at five or ten cents per call, it may be possible to predict how many calls 100,000 John Smiths will make.

From this point of view, mathematical economics is not unlike what mathematical physics is becoming.

EARLY USES OF MATHEMATICS IN ECONOMICS

In 1838, Augustin Cournot succeeded in driving the entering wedge of mathematics into economics when he published his "Researches Into the Mathematical Principles of Wealth." Cournot cited a paper by Canard, 1801, that had been approved by the French Institute, but said:

"These pretended principles are so radically at fault and the application of them is so erroneous that the approval of a distinguished body of men was unable to preserve the work from oblivion."

However, in a bibliography of mathematical economics at the end of the MacMillan edition of Cournot, Prof. Irving Fisher cites twenty-seven papers and treatises before Cournot. The earliest one was published in 1711.

Although Cournot wrote almost a century ago, many of his ideas seem to be quite modern. For example, Cournot's words, "It would seem proper to first investigate the causes which produce absolute variations in the value of the monetary metals, and when these are accounted for, to reduce to the corrected value of money the variations which occur in the value of other articles," have been echoed and paraphrased many times by modern economists. Practically every one realizes that gold has appreciated during the last few years, or what is the same, that prices of other goods have fallen.

In addition to his work on the theory of value, Cournot developed theories of exchange, monopoly, competition, and others.

The literature of mathematical economics is now quite large. In fact, it is too large to be surveyed in an adequate manner in a short paper. Since Prof. Irving Fisher has made a general survey of the contributions of mathematics to economics in the Gibbs Lecture for 1929, which he delivered before the American Mathematical Society, it would be superfluous to do the same sort of thing here. It seems best, therefore, to devote this paper to some particular phase of mathematical economics.

A STUDY OF THE THEORY OF DEMAND OUTLINED

For an engineering audience, an exposition of the theory of production might prove interesting. Thus, the theory of quality control of the manufactured article, to which Dr. W. A. Shewhart has contributed so much, would be a likely subject.

However, every one is interested in demand in some form or other—demand for goods, for labor (including engineers), and so forth. Furthermore, there is some hope of immediate determination of statistical laws of demand that might prove useful. For these reasons, the remainder of this paper is devoted to a study of demand phenomena.

This study of demand deals chiefly with the effects of past prices, present prices, and expected future prices upon demand. It is shown that the effects of these quantities can be best considered by using the theory of integral equations—since the very definition of an integral makes it a function of all points of a curve—for the demand problem, the curve represented by price as a function of time.

In the study of production to which this paper is directed, it is postulated that demand depends upon present and past prices, and it is shown that this assumption leads quite naturally to an integral or to a functional equation of demand. In the simplest case, the statements (1) demand depends upon past prices and (2) price depends upon past demands, are shown to be entirely equivalent, because of the invertibility of the integral equation.

Present demand is assumed to consist of (*a*) consummations of past decisions to purchase as soon as funds become available, (*b*) climaxes of growing desires to purchase, and (*c*) purchases that are called forth chiefly by the present price of the goods. For (*a*), many will make their purchases within a relatively short time, and some will never be able to purchase. This situation may be typified by assuming that the factors affecting the periods of time required for the transformation of desires to purchase created at time t_1 into actual purchases at t are such that decisions to purchase are transformed into purchases according to a Pearsonian Type III frequency function. For this function and certain other somewhat similar ones, it is shown that the continuous weight function for past prices is of the type $f(x)K(x-t)$, where x refers to past time and t to present time. The form of this function is derived. For (*b*), it is shown that the demand depends less and less upon past prices as the time is more and more remote, and a typical form of weight function is suggested.

It is further assumed that speculative demand depends upon expected future prices, and that the demand law for the common situation of predicting prices one unit in advance of t consists of a function of p, a functional of p, and an expression involving the derivative of p with respect to time t. There is given a discussion of time lags, and a functional elasticity of demand is defined. This is a new concept.

DISCUSSION OF DR. ROOS'S PAPER

Dr. Henry Schultz, of the University of Chicago, read a very able discussion of Dr. Roos's paper. He called attention to the fact that equations of demand were frequently referred to as "dynamic" equations, and went on to say that much nonsense had been said and written about statics and dynamics in the social sciences.

Every economic system, he said, presented considerable resistance to the internal or external forces which tended to modify it. When the accidental movements which originate in the economy were completely neutralized by the movements in the opposite direction to which they gave rise, we had a statical equilibrium. When the entire economy was carried along by a general movement which modified it slowly, we had a dynamic equilibrium.

Using as an analogy the dynamic problem of a physical system, he asked, "What equations of motion, and what laws of conservation of comparable scope do we have in economics?" There were none, he said. Thus our economic laws of change were simply empirical extrapolations of the present situation; they did not enable us to determine what, for example, the demand and supply situation would be at the next instant of time.

With respect to the second problem, namely, how would the demand curve move at a *finite* time later, we were even more helpless, he continued. True, we could write down equations which were analogous to the laws of conservation, to the principle of virtual movements, etc.; and we could think of the total utility function—if it existed—as corresponding to the energy potential whose partial derivatives measured the forces which guided the movements of the individual. But, unfortunately, we knew neither the values nor the forms of the required functions.

The best that we could do at the present stage of our knowledge was to make a study of a series of statical equilibria, isolate their routine of change, if it existed, and hope that this routine would continue to operate in the future.

It was such a routine that was represented by Dr. Roos's equations, said Dr. Schultz. The same routine of change might also be represented by an infinitude of other equations.

DEMAND AND COST ANALYSIS IN PUBLIC-UTILITY FIELD

Dr. Schultz then made use of two illustrations which are quoted in full. He said:

The following illustrations of the importance of a knowledge of the routine of change of demand and supply should be of particular interest to engineers.

One of the oldest and best-known utility companies in the United States had occasion to change its rate schedules for gas and electricity in a certain city several times in the last decade. Each change was made upon the recommendation of a firm of consulting engineers, who attacked the problem by the time-honored method of projecting trends of consumption. It occurred to a young engineer in the employ of the public-utility company to try a procedure for estimating the most profitable rate structure different from that followed by the engineer. Having come across a recent work on statistical demand curves, he decided to adopt the methods of modern economics in preference to those used by the consulting engineers. He thereupon made an analysis of the records in the company's files, and deduced from them concrete statistical demand curves for electricity for the more important groups of consumers. Bringing these demand curves into conjunction with the curves of cost of production, he computed the rate structure that would maximize the company's earnings. His findings differed widely from those obtained by the hit-and-miss methods of the consulting engineers. He was able to show that his company was losing vast sums of money through its adherence to an uneconomic rate structure, and furthermore, that the optimum rate structure from the company's point of view would also have been more favorable to the consumers.

I am reliably informed that a thorough-going application of modern demand and cost analysis to the public-utility field would work a veritable economic revolution in this industry.

THE DIFFERENTIAL COST FUNCTION

For my second illustration, I may take the problem of supply or of cost of production. Engineers and cost accountants generally compute the average cost of the entire output of a plant to four or six significant figures, and then attempt to convince the owner, against his better business judgment, that he ought not to sell at a price that does not cover this average cost. But the average cost of production includes overhead, and charges for overhead should be given no consideration in any rational economic determination of the output that is to be placed on the market. The economically significant item is the differential cost function, i.e., the function giving the cost of producing one *additional* unit (or lot), when n units have been produced. The economically intelligent business man, operating under conditions of free competition, will adopt that scale of output for which the differential cost will be just covered by the price. To compute the average cost to four or six significant figures is a waste of time and energy, for the resulting figure is perfectly useless. To compute the differential cost function, even when the error in it is as large as 10 per cent, is, however, to obtain a very good indication of the most profitable output under varying price conditions. I believe that the present foolish practise of basing output and prices on average costs, rather than on differential or marginal costs, is responsible in some measure for the prolongation of the depression.

MATHEMATICS CANNOT WORK MIRACLES

In closing, Dr. Schultz said:

Important as the contributions of engineers to economics have been, they pale into utter insignificance when compared with what they might have been had economists known more mathematics and technology and had engineers known more economics. However, let not the engineer lull himself into the comfortable but erroneous belief that because he knows more mathematics than do most economists, he can master the principles of economics without much serious and sustained effort. There is every difference in the world between studying economics *with* mathematics and studying it *as* mathematics. A knowledge of mathematics cannot work miracles. The college graduate of today who has majored in mathematics knows more mathematics than did Newton. Yet that does not make him a Newton. To make more rapid progress in the development of the border field between engineering and economics, our schools of technology will have to make room in their curricula for the principles of price making and be on guard against the phrasemakers. Will they rise to their opportunity?

II—MATHEMATICAL THEORY OF RATIONAL INFERENCE

Dr. Thornton C. Fry's cleverly written and admirably presented paper on "The Mathematical Theory of Rational Inference" dealt in a lucid and interesting way with the tossing of a coin to determine whether or not it might have two heads. By means of this simple illustration, he sought to show the validity of Bayes' Theorem that may be written in the form $P = EL/S$; in which P is the desired *a posteriori* probability, measuring the degree of assurance justified by both the statistical and collateral information; E is the existence probability, which measures the contribution of collateral information to the sum total of our knowledge and includes everything but the statistical information considered in arriving at an estimation of likelihood; and L is the likelihood, a concept defined in popular terms as "the probability of getting our data if the assumption is true." The term S is a scale factor which is the summation of the product EL.

Dr. Fry showed how the statistical evidence that the coin might have two heads would grow to astronomical proportions if a continuous string of heads resulted from the flipping of a coin. Common sense, however, would make us loath to believe that there actually were two heads, because we had

never seen such a coin, unless, perhaps, we had some collateral information, such as, for example, that some two-headed coins had, by mistake, got into circulation. And even if there were no such coins, there would still be the possibility of what may be termed, for lack of a better word, "fraud," i.e., the coin tosser might be manipulating the tossing to perpetrate a fraud. Thus, thoroughness in examining for such a possibility would be advisable before trusting implicitly to the statistical evidence, even when tempered with the collateral information.

So in the end, he concluded, every letter in Bayes's formula had carried a lesson about the formation of a rational judgment: *L* had told us what help we could reasonably expect from the statistician, *E* had emphasized the need for common sense, and *S* the need for thoroughness. There might be nothing epoch-making in the assertion that all three were needed in arriving at a trustworthy inference from statistical data. He was not without hope, however, that the picture which he had given of all three flowing logically from one small part of the theory of probability might serve to reassure his listeners that that theory was not concocted out of the ethereal imagination of the mathematicians, but was, instead, a very matter-of-fact affair when properly understood. If in this way he had contributed to the ease and assurance with which engineers could deal with statistics and statisticians, his object would have been attained.

DISCUSSION OF DR. FRY'S PAPER

The discussion of Dr. Fry's paper was led by Prof. Harold Hotelling, of the Faculty of Political Science, Columbia University, who expressed another view with regard to the subject. His discussion does not lend itself to abstracting as it must be read in connection with Dr. Fry's complete paper.

Dr. Anson Hayes, director, Research Laboratories, The American Rolling Mill Co., Middletown, Ohio, wrote that the paper had an important and practical bearing on the work of the American Society for Testing Materials. He said that the society was incorporated for the purpose of promoting knowledge of engineering materials and the standardization of specifications and methods of testing.

This work involved at every turn the collection and utilization of vast quantities of technical data. Such data formed an important part of the source material used in arriving at standards. These standards had to be satisfactory to both the consumer and the producer. One of the most important problems was that of interpreting the experimental data thus obtained. Interpretation consisted essentially in formulating judgments based on the immediate data and also on all of the relevant collateral information. These judgments were invariably probability judgments, as Dr. Fry had indicated, and the conclusions reached were therefore never certain.

There were two thoughts that Dr. Hayes wished to leave with the meeting:

(1) The philosophy of probable inference was one of the fundamental tools that must be used if we were to attain an objective of choosing quality standards that were economic.

(2) To attain this objective, there should be in each branch of industry interested in standardization, a few men, highly trained in the philosophy of probable inference, who could aid in the development of techniques for establishing and maintaining economic standards of quality.

L. K. Sillcox, member A.S.M.E., said that it was well to emphasize that the inductive probability inference in design and development effected economies in engineering work. Most engineers realized the practical significance of the studies in the mathematics and philosophies involved, and it was indeed a hopeful sign that committees had been established to cooperate in the establishment of more efficient engineering practises, in the field of discovery and use of engineering and social data.

III—THE ENGINEERING ECONOMIST OF THE FUTURE

Dean Kimball's paper, "The Engineering Economist of the Future," will be found elsewhere in this issue. It emphasized particularly the caution an engineer should exercise in the field of economics in order to avoid the perils of dogmatism and false prophecy, and urged him to make a long and careful study of the subject and of human society before venturing to imagine that his own thinking was clear and faultless.

Rising in militant spirit to defend engineers who had, recently, thought on economic subjects and at times arrived at conclusions at variance with those reached by classical economists, Dr. Harvey N. Davis, president of Stevens Institute of Technology, interpreted Dean Kimball's paper as saying that engineers should interest themselves in economics but not take themselves or their conclusions too seriously. It was, he said, a case of "hang your clothes on the hickory limb, but don't go near the water."

He then propounded the "Corliss Engine Theory of Pious Platitudes," which, by an analogy of the relative importance of a knowledge of dynamics in designing a connecting rod for a slow-speed Corliss engine and a high-speed internal-combustion engine, illustrated how the "static" economics of an agricultural civilization had to be replaced by the "dynamic" economics of an industrial civilization.

C. F. HIRSHFELD EMPHASIZES CAUTIONS

C. F. Hirshfeld, in a written discussion, emphasized Dean Kimball's cautions regarding any happy-go-lucky type of attack on the problems of economics. The field was very broad, he said, world-wide, in fact; and the subjects that had to be considered were multitudinous, intimately interlocked, and, in many cases, imperfectly understood.

In his opinion, economics was a "science in the making." He believed that the study of economics had suffered from a very common failure to define terms and concepts rigorously and then to think and reason always within the terms of such definitions.

The comparatively recent tendency to introduce mathematical methods into the field of economics, he continued, would undoubtedly have a salutary effect in such respects. From one point of view, mathematics was really nothing but shorthand expression for what could be put in words or thought, but it had the advantage of such stark realism that one was quickly driven to recognize confusion of definitions.

Furthermore, the subject of economics was, in his opinion, a specialized branch of psychology.

In the ultimate end, he said, it endeavored to account for certain behaviors of people in large groups. The things of which the economist spoke and wrote were of importance only as they explained the behavior of the human social organism; of themselves they meant nothing at all. They were devices created by man for his own purposes and had now become so significant in his existence that many of his most important acts, movements, and reactions could be explained if we could discover all the stimuli resident in them at any given time and then interpret them correctly in terms of individual and mass reaction.

USEFUL SERVICES OF ENGINEERS TO ECONOMICS

In conclusion, he said that to his mind the engineer could perform a useful service in the field of economics. But he

would do it, if he did it, as an effort supplementing that of others rather than as an original and self-contained endeavor. In fact, any scientifically and mathematically trained individual could render a useful service at the present time by bringing in the truly scientific method, first, as a means of testing and evaluating present concepts and theories, and second, as a means of advancing in a more rigorously scientific fashion beyond the present state of the subject. Engineers with proper training and enthusiasm could probably do a still better job than pure scientists because of their inherent desire to achieve practical working results rather than being satisfied with explanations of why and wherefore.

But, like Dean Kimball, he wanted to stress the futility of engineers' attempts to enter the field of economics unless they were willing to devote time and energy to the intensive and rigorous study of the history of humanity and the history of economics as a groundwork for an engineering method of attack upon these entrancing but very confusing problems. And, in closing, he cautioned such as were willing to undergo such rigid discipline to remember always that in this field they did not deal with equations in which parameters were expressible solely in such readily determinable things as masses, forces, fields, and the like, but that back of all of them lay that peculiar organism known as the human being. It was his reactions to stimuli of various sorts that constituted what Mr. Hirshfeld was sufficiently optimistic to believe would ultimately be a true science of economics.

IV—SOME FUNDAMENTAL PROBLEMS OF THE ENGINEER

At the evening session, Dr. F. B. Jewett's address related to "Some Fundamental Problems of the Engineer." He spoke extemporaneously, and the following résumé was prepared from notes hastily taken at the time.

Dr. Jewett began his address by defining the engineer as "a technical artizan who takes the facts of fundamental science and mixes them with dollars in the creation of things of utility or pleasure." Starting with such a definition, it was clear to him that the engineer should be interested in economics and in the broad problem of production, as it was the engineer's fundamental function to produce things of commercial or utilitarian value.

Originally, he pointed out, engineers were not interested in the social consequences of their acts because of their primary and absorbing interest in creation. Engineering education, even, had acquired this fundamental problem of concerning itself with the ways and means of developing men to become engineers in this original and generally accepted sense of a creative worker.

At the present time, however, as Dr. Jewett ably pointed out, the situation had changed markedly, and the reason for this change lay in what engineers themselves had brought about. This raised new problems for the engineer of the future.

Asking himself what problems confronted engineers in the future, Dr. Jewett found that the answer led back again to engineering education, but to a form of education in which there was a change in emphasis. His subject was to deal with these fundamental problems of the future.

COMING TOGETHER OF ENGINEERS AND ECONOMISTS A HAPPY AUGURY

It was a happy augury, he thought, that engineers and economists had come together for a discussion of their common problems. He pointed out that the forces that had brought about the joint meeting at Chicago were the same as those which resulted in A Century of Progress Exposition. For it had been the primary thought of those who planned the exposition that there existed a growing realization that the machine age had raised problems of social and political control that had outstripped in significance and importance the more material problems of an earlier age. For these problems there could be no adequate solution, unless the rank and file of the thinking people had an understanding of the underlying forces governing the effects of the applications of scientific knowledge to the uses of mankind. For this reason, some vivid illustrations of what science had wrought, and of the simple fundamental progenitors of more modern developments, were necessary. Those had been provided by the exhibits at the Exposition, particularly those in the Hall of Science.

It was for the same reasons, Dr. Jewett argued, that engineers and economists had been brought together. Both had been critical of the ultra-conservatism of non-technical persons who, they believed, had refused to adopt into modern life what science had to offer, and thereby had failed to exercise proper control of these newer forces over the body politic.

LACK OF APPRECIATION OF SOCIAL PROBLEMS

In taking this position, Dr. Jewett said, engineers were in the dangerous position of living in glass houses. Engineers themselves, he contended, had also lagged in the adaptation of the discoveries of science and had concerned themselves solely with those of an obviously utilitarian value. They had not concerned themselves with social problems.

There was here, he pointed out, an inevitable sequence in the relationships of the various professions. As the discoveries of value to mankind were made by the scientist, they were dealt with in a natural sequence by scientist, engineer, economist, manager, banker, and lawyer, and it was inevitable that there should be a considerable time lag in the process of passing through the practises of one profession into those of another. The spread of knowledge, he reminded his audience, was necessarily slow, and some time lag in the adaptation of new scientific discoveries to the various professions was probably desirable.

Addressing himself next to the question of what could be done, Dr. Jewett expressed the opinion that we should consciously reduce the time lag between science and engineering and between the developments of applied science and the understanding of them by those who must use them. In this process, one of the first groups engineers came in contact with was that of the economists.

ADVANCE OF PROGRESS ACCELERATED BY ENGINEERING

Historically, said Dr. Jewett, the economists had lagged behind the development of the sciences. There was a time when economists did not vigorously set about finding out what the changes wrought by applied science were and what the consequences of such changes might be. In these collateral effects, engineers also had had no interest, and had made no attempts to point the way of economics or social progress, even though engineering had accelerated social and economic change.

Engineering progress itself was slow at first, Dr. Jewett pointed out. Based on the scientific method, it progressed on the basis of new facts and controlled experiments, and its concerns lay with these acquisitions to knowledge. Gradually, thoughtful persons were attracted into the field of engineering as cheaper and better ways of making things offered opportunities for gain; and the speed of growth of applied science increase enormously. Doubly accelerated by reason of the fact that engineers had implemented industry with scientific

tools, the cooperation between appliers of science and pure science speeded progress still further, resulting in unexpected and enormously important problems in governmental, economic, and social control. That engineers and economists might cooperate was an evidence of the beginnings of more orderly control.

In the process of control—social, economic, and political—necessitated by the rapid changes wrought by the machine age, engineers must be of help, Dr. Jewett insisted. For if they did not know, who did? he asked. From this, he argued, the most fundamental problem of engineering had nothing to do with the creation of more new things, this being inevitable, in his opinion, but it was for the engineers to set their minds to find ways and means of being sure what their social and political contributions should be, and to pass this on to society.

NEW SIGNIFICANCE OF ENGINEERING EDUCATION

In carrying out such a program, Dr. Jewett said, education played an important part, and hence engineering education took on a new significance which was to modify the preconceived idea that the world had about the relations of science and engineering to social and political problems.

Among the bilateral effects that contacts between economists and engineers would provide would be this educational opportunity, from which, as Dr. Jewett expressed the hope, there might spring a wisdom on the part of engineers to create things they could control and to provide for a proper distribution of the benefits to be derived from the substitution of mechanical for human power.

Speaking figuratively of the change in engineering as a result of the adaptation of scientific discoveries, Dr. Jewett expressed the opinion that early engineering structures were gross because materials were gross. But as the blocks were made smaller and smaller by means of advancing knowledge, structures could be made finer and of more pleasing proportions. New and more certain knowledge tended to eliminate the unknown. Thus, he argued, factors of safety, which engineers introduced actually as factors of ignorance, become smaller as knowledge increased, resulting in the decrease of costs and also with the impingement on society of more economic, social, and political problems.

A CONCEPT OF EDUCATION

How should engineers use the knowledge resulting from the advancement of science? asked Dr. Jewett. In his opinion, success would depend on some engineers' finding their way into the non-technical groups. This made it necessary, he said, to find ways of selecting and training men who could pass over from the technical field into economics, finance, politics, and positions of social control. A training for such leaders, he thought, would consist of a preliminary study of science and engineering, supplemented by instruction from wise leaders in economics and the social sciences.

As an example of what had taken place, Dr. Jewett cited the case of the patent attorney. The most eminent of this profession had had a broad cultural training, an engineering, or a legal training, or having combined some two of these and then on them superimposed the technique of patent law.

Such a concept of education, Dr. Jewett maintained, would fit into our present and future social structure, for if we made full use of science, we would have more leisure, and hence more time for education. Greater leisure, in his opinion, was not a matter of shorter hours and shorter work weeks, but of providing more time at the start of life for education and training, and more time at the end of life for the enjoyment of the well-earned satisfactions of old age. Such distribution of leisure seemed desirable to him, and possible of attainment.

V—INTERNATIONALIZATION OF SCIENTIFIC KNOWLEDGE

To a closely attentive audience, Dr. A. P. M. Fleming, as the concluding speaker on the econometric program, spoke with great earnestness and conviction on the "Internationalization of Scientific Knowledge as a Factor in World Economic Recovery." It was his purpose to direct attention to the economic possibilities of internationally concentrating and disseminating scientific knowledge and experience, and the subject was, in his mind, important, as it bore on two significant problems:

(1) The social-economic problem of unemployment which was world-wide in all countries except the Union of Socialist Soviet Republics.

(2) The imminence of the challenge of industry as planned under the commercial system of the U.S.S.R. to that planned on the individualistic and competitive system in other countries.

Dr. Fleming said that the fact that the distribution of natural resources bore no relation to political boundaries was a fundamental reason for international cooperation in regard to their effective use by the community. In the early stages of supply, local markets had advanced to a point where industrial groups of different countries were interlinked internationally. Inventions and discoveries, he pointed out, soon became international, and the development of similar types of industries in different countries demanded a universal supply of raw materials. However, in spite of this international interdependence on raw materials and markets, restrictions had been set up to hamper interchange of supply and demand. In his opinion, it was significant that, under the threat of military aggression, nations deliberately cooperated to establish the means for the destruction of material assets, an impulse that was singularly lacking at the present when there was a great need for cooperative effort to reestablish world economic prosperity.

UNEMPLOYMENT

Turning to the subject of unemployment, Dr. Fleming pointed out that as manufacturing industries had grown from local to national, and from national to international proportions, the problem of unemployment had developed correspondingly. Continuing, he said that with increasing competition between manufacturers in the same industry and between manufacturers nationally and those competing in international markets, the importance of improved methods of manufacture had become emphasized, and increasingly scientific knowledge had been employed to effect improvements resulting in the saving of time, effort, and materials. When traced to their ultimate conclusion, these improvements in manufacturing efficiency were only secured by eliminating labor, that was to say, by increasing unemployment.

Improvement in efficiency, he said, gave an individual manufacturer advantage over his competitors and enabled him to secure thereby a greater part of the market, but the net result of this was to increase unemployment in his particular country. If a group of manufacturers by improved methods secured a greater share of the international market, then employment in the one country was increased, but internationally, the sum total of employment was decreased.

The great efforts that had been made—organized in some countries on national lines—to apply scientific knowledge by means of industrial research to effect industrial economies had, for the most part, increased unemployment rather than diminished it. It must be recognized, however, that as a national safeguard, such efforts were of the utmost importance. Also, as a phase of world economic progress, they were equally of

great significance, since they conserved the total world economic resources.

It may be rightly argued, said Dr. Fleming, that if improvements in manufacture resulted in a greatly cheapened product, this would stimulate an increase in demand which would balance the loss of employment that would otherwise occur. This argument was only partially true and failed badly when times were not prosperous.

DEVELOPMENT OF NEW INDUSTRIES ESSENTIAL

An important point to note, he said, was the development of new industries as an alleviation of the depressed industrial conditions. In seeking a solution to this unemployment problem, it was right to start with the manufacturing industries, because every worker directly employed in manufacture led to the indirect employment of many others. For example, in general engineering, the employment of an additional fitter would mean the indirect employment of probably three other workers, who would be concerned with coal mining, mining of iron ore, production of pig iron, its conversion into steel, the rolling of the steel into various shapes, and in the various stages of transport to the engineering works and the subsequent transport from the works of the finished product. In some industries, the ratio of direct to indirect employment was much greater. In considering, therefore, the establishment of new lines of industrial activity to alleviate unemployment, attention should first be directed to manufacturable products.

The birth of an idea, he continued, was the starting point of a new line of industrial activity. Ideas might spring from a variety of sources, but increasingly they came from scientific and technical workers. It was the conversion of the abstract idea to a concrete entity which enabled the establishment of commercial enterprise and subsequent employment. For example, the ideas that emanated from Faraday, Henry, and others, a century ago, had brought about the great electrical industry which today employed many hundreds of thousands of workers. Similar examples might be quoted in the chemical, metallurgical, and other industries. Bridging the gap between the abstract idea and the concrete object proceeded, in principle, through certain definite stages; first, testing the truth of the idea, experimentally; then research to determine the possibilities of industrial application; then the trial on a sufficiently large scale to test its commercial and economic possibilities; and finally, finance was necessary for the establishment of the productive facilities.

Today, throughout the world, he pointed out, there were large numbers of scientific and technical workers employed for the most part in the improvement of methods of industrial production, but to a much less degree was there purposeful and organized activity of such workers in the development of entirely new lines of industrial activity.

The great reservoir of experience and knowledge, which was being continually augmented, was the potential source of new lines of manufacture which could be developed to alleviate the problem of unemployment. Individual firms were using their resources to this end, but as yet its possibilities on a national and international scale had not been recognized.

RELATION OF U.S.S.R. TO OTHER COUNTRIES

On the subject of the U.S.S.R. in relation to other countries, Dr. Fleming said that the U.S.S.R. comprised one-sixth of the earth's land surface and had a population of nearly 150 million people of 200 different nationalities. Within its borders, it contained most of the natural resources required by man, and its government aimed at developing these for the benefit of its own people, with a view to making the standard of living as high as, if not higher than, that of other countries. Here existed a great number of nationalities already internationalized in the most complete way, with the absence of tariff barriers, international currency restrictions, and without any diversity of internal political aspirations. The U.S.S.R. plan had been to divide manufactures into certain definite branches, such as those relating to the heavy industries, the light industries, power production, and raw material resources. Each of these groups constituted a trust, with the productive units coming under one control and having common research and educational organizations. Research, including that of a fundamental character, came under the control of one department of the state, so that all scientific work could be coordinated. Great expenditure had been incurred in setting up the most up-to-date laboratories and in the selection and training of research workers. While their research activities were to a large extent imitative, considerable progress had already been made, and there was in the U.S.S.R. a larger body of organized research workers under unified control than existed in any other individual country in the world. The Soviet Government was looking to science to play a most important part in its industrial and economic activities.

THE CHALLENGE OF THE RUSSIAN SITUATION

Whether the Soviet plans succeeded or failed, said Dr. Fleming, already enough had been accomplished to show the possibilities of this combined scientific effort. Even partial success might have far-reaching effects on the rest of the industrial world. Should the standard of living be raised to the same, or to higher, levels than those of other countries, and, as might in time reasonably happen, hours of labor be shortened, there would be a considerable degree of labor unrest in other countries. Moreover, the possibility must not be overlooked that Russia might tend to become a great exporter of manufactured goods. This situation was developing at a time when there was little industrial cooperation between the other countries, and there was no doubt that this challenge of a communal to a competitive plan justified a careful consideration of the advantages of further cooperation, especially in the matter of pooling of scientific resources and experience. With the lead that the foreign manufacturing countries jointly possessed, and with the fullest use being made of their joint scientific resources, it should be possible he said, to meet this challenge successfully.

In conclusion, he said that the internationalization of new scientific knowledge was already well established, since it was the custom for workers in pure science to make known their discoveries as soon as they had succeeded in verifying them. In the case of science applied directly to industrial objectives, disclosure of the technical results was restrained for obvious commercial reasons and protection, either by patent or secret process, sought in order to reap a financial reward for the expenditure incurred.

Protection of this kind, he said, was not so effective today as it had been heretofore, since the facilities provided by modern scientific and technical resources were such that an objective once attained could, if sufficiently coveted, be attacked from so many angles that patents were likely to be circumvented and secret processes revealed.

Taking this into consideration, recognizing the increasing need for all kinds of international cooperation; having regard to the challenge of the U.S.S.R.; and above all, viewing the importance of the social-economic problem of unemployment, there appeared to be great justification for a consideration of the pooling of scientific resources and experience for the ultimate common welfare of all countries.

The BREAK-EVEN CHART

Some Practical Limitations to Its Use

By H. R. MALLORY[1]

IN THE November, 1932, issue of MECHANICAL ENGINEERING, there appeared a paper by Walter Rautenstrauch entitled "Economic Characteristics of the Manufacturing Industries." Professor Rautenstrauch's work is undoubtedly of great value and should lead to a better appreciation of the dynamic rather than the static quality of expense. Without in any way detracting from Professor Rautenstrauch's paper, the author wishes to point out certain dangers in connection with a literal application of the equations it presents. To this end, the break-even chart used by Professor Rautenstrauch in his paper has been reproduced, and in addition, in order to show the evolution of a practical working chart from the theoretical chart, five other charts have been prepared.

THE CONVENTIONAL BREAK-EVEN CHART

Fig. 1 is typical of the conventional break-even chart used by Professor Rautenstrauch in the development of the various equations presented in his paper. The line of "income" crosses the line of "total expense" at 71.4 per cent of plant activity. When operation is above 71.4 per cent of capacity,

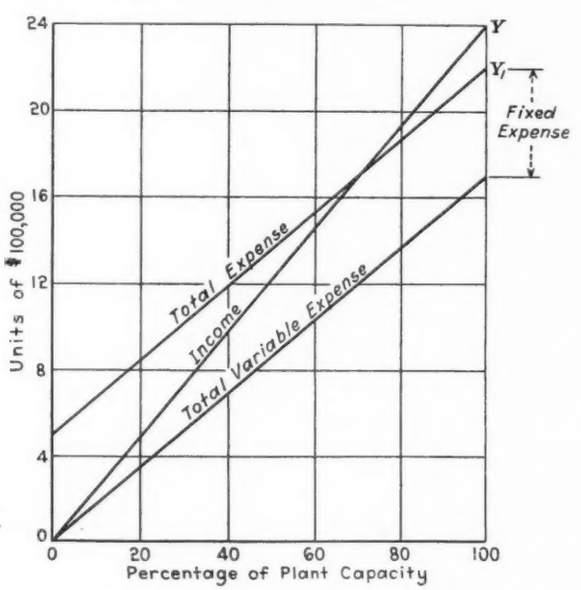


FIG. 1 DIVISION OF TOTAL FIXED AND VARIABLE EXPENSE ON THEORETICAL CROSS-OVER CHART

income exceeds total expense, and below this point, the total expense is greater than the income. The difference between income and total expense at greater capacities than 71.4 per cent represents profit; below this point, it represents loss. Fixed expenses are constant between 0 and 100 per cent of capacity. Variable expenses follow a straight-line relationship, being directly proportional to plant activity.

[1] Cheney Brothers, South Manchester, Conn. Mem. A.S.M.E.

CLASSIFICATION OF FIXED AND VARIABLE EXPENSES

Fig. 2 shows the same total fixed expense and total variable expense that is shown in Fig. 1, and in addition, shows a further classification of the fixed and variable expenses. This additional classification is made in order that the major items of expense may be grouped for the purpose of controlling expenses in relation to volume of business done.

Let us assume that the normal activity of the business dia-

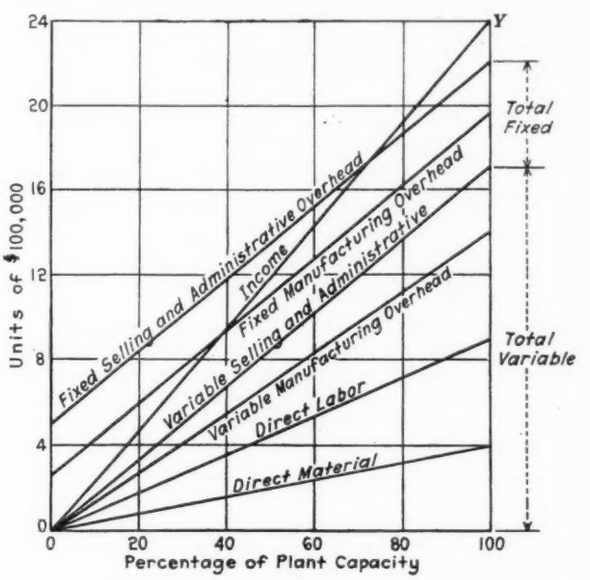


FIG. 2 MAJOR CLASSIFICATION OF FIXED AND VARIABLE EXPENSE

grammed on the chart is 80 per cent of capacity and that prices are set for the various products on the basis of running normally at that activity. The normal budget and sales dollar are then composed of the elements listed in Table 1.

TABLE 1

	Total dollars, 80% capacity	Sales dollar
Direct material	320,000	0.166
Direct labor	400,000	0.208
Variable manufacturing overhead	400,000	0.208
Variable selling and administrative	240,000	0.125
Fixed manufacturing overhead	260,000	0.135
Fixed selling and administrative	240,000	0.125
Profit	60,000	0.033
Sales income	$1,920,000	1.00

NOTE: The figures used are for purposes of illustration only and present a higher percentage of overhead than normally would be found.

If prices are set on the basis of a normal activity of 80 per cent of plant capacity, it is apparent that from each dollar of income, there is only $0.208 to pay for direct labor, $0.208 for variable manufacturing overhead, $0.135 for fixed manufactur-

ing overhead, etc. If the volume of sales falls to 40 per cent of plant capacity, the sales income is then $960,000, which is one-half the normal sales income of $1,920,000 at 80 per cent of plant capacity. If we consider the allotment of $0.208 per dollar of income for variable manufacturing overhead and the amount of $0.135 for fixed manufacturing overhead, it becomes obvious that if the income is cut in half, the allotment for the expenditure for variable manufacturing overhead is cut in half, and the same is true of the amount for fixed manufacturing overhead, as well as for all other items of expense. It is apparent that for the purpose of controlling expenses, the ideal method would be to keep all expenses within the sales dollar allowance established as sales volume falls and income decreases.

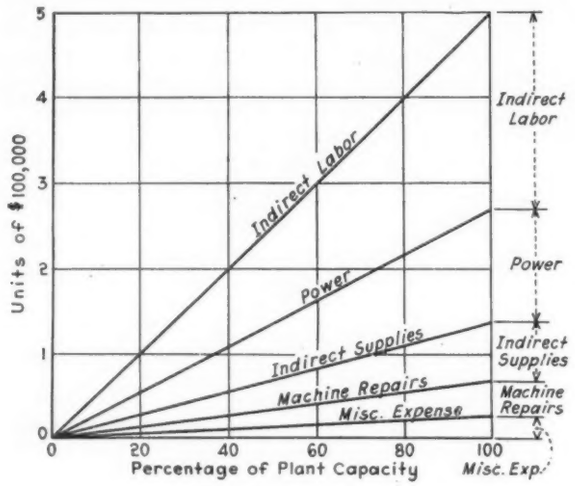


FIG. 3 VARIABLE MANUFACTURING OVERHEAD

Since the ratio of a given percentage of plant capacity to 100 per cent capacity is the same as the ratio of the corresponding sales to sales at 100 per cent of plant capacity, we may say that the sales dollar allowances decrease in direct proportion to plant activity. Professor Rautenstrauch explains the temporary derangement of the relationship between plant activity and income that often occurs when inventory is built up in advance of the selling season, and he clearly demonstrates that this does not affect the fundamental relationship. Now there are certain expenses that tend to remain constant as the volume of sales or production decreases, and there are other expenses that may readily be decreased as activity decreases, but which cannot be reduced in direct proportion to activity. While the sales dollar establishes a task that is practically impossible to attain, as it requires a reduction of all expenses in direct proportion to activity, it indicates the necessity of examining every item of expense in order to see how it may be reduced as activity decreases. The following paragraphs describe some of the methods that have been applied practically in order to accomplish this result, and also illustrate the necessary modifications in the break-even chart in order to make it most useful to the individual manufacturing business.

A BREAK-DOWN OF VARIABLE MANUFACTURING OVERHEAD

Fig. 3 represents the segment of variable manufacturing overhead[2] shown in Fig. 2, broken down into further detailed elements and plotted to the same scale as Fig. 2. It is desired to control the items of expense shown on this chart, as mentioned in the preceding paragraph, as nearly as possible in direct proportion to the plant activity. There are two other major items of variable manufacturing expense shown in Fig. 2 that are not shown in Fig. 3, because Fig. 3 is made up of the variable manufacturing overhead alone. However, it is well to consider the two items of manufacturing expense referred to, which are (*a*) direct material and (*b*) direct labor.

It has been demonstrated in actual practice that it is possible to control these expenses in direct proportion to plant activity (allowance being made for fluctuations in raw-material market prices). Various ways and means of doing this are used in different industries. It has not been found possible to control the items of variable manufacturing overhead in the same manner; therefore, some method must be devised that will enable us to set limits of variation from the straight-line relationship, so it may be used for budget and control purposes. Deviations from the straight-line relationship for indirect expenses are caused by the necessity of running elevators, oiling shafting, repairing belts, main motors, switches, etc., even though some of the machines which are serviced by them may be idle due to reduced volume of business.

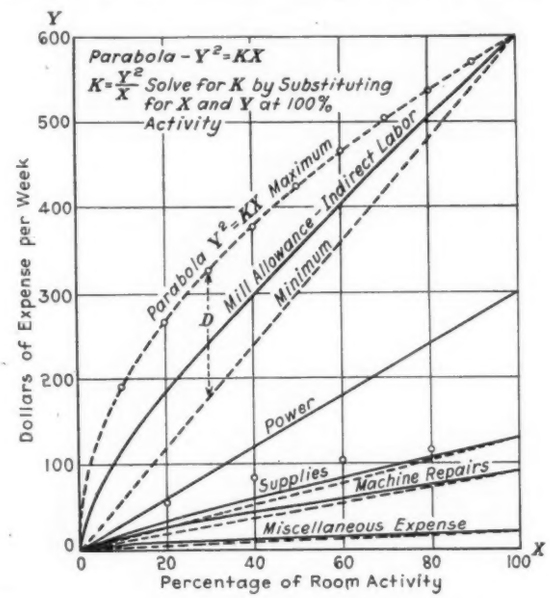


FIG. 4 MILL ALLOWANCES FOR CONTROL OF DEPARTMENTAL ROOM VARIABLE EXPENSE

Indirect labor	$K = 3600$	Mill allowance = 40 per cent of D
Indirect supplies	$K = 169$	Mill allowance = 25 per cent of D
Machine repairs	$K = 81$	Mill allowance = 25 per cent of D
Miscellaneous expense	$K = 4$	Mill allowance = 25 per cent of D

Variable power mill allowance is a straight line (fixed expense of power plants is included in production department fixed charges).

MILL ALLOWANCES FOR CONTROL OF DEPARTMENTAL ROOM VARIABLE EXPENSE

Let us assume that the plant is divided into many departments or areas of expense control and that over each department is a foreman who controls, in addition to direct labor and direct material, the following items of expense: (*a*) indirect labor, (*b*) power, (*c*) indirect supplies, (*d*) machine repairs, and (*e*) miscellaneous expense.

If we consider one room in which there are, for instance, 400 machines, it is possible to establish with accuracy, after

[2] There is no uniformity to the method of classification of expense in industry, so that it is quite possible that an item of expense that is truly semi-fixed may be classed as variable in one industry and fixed in another.

careful study, the amount of indirect labor required when all of the machines are in operation. Similarly, it is possible to establish the required amount of expense for power, indirect supplies, machine repairs, and miscellaneous expense. The readings in dollars at 100 per cent activity in Fig. 4 represent the controllable indirect variable expenses required when the room is running at full activity. The scale of the chart has been set so as to provide the readings in terms of expense per week, instead of annual expense. However, the sum of all the expenses shown on the chart added to the sum of the weekly expenses for the same class of expense, for all of the departments or burden centers in the plant, multiplied by 52 (to convert to an annual basis) will equal the expenses that are shown in Fig. 3.

The readings in Fig. 4 should be made from the base line up to the line of expense in question. In the preceding charts, the expenses were added, one to the other. On either form of chart, a straight line, passing through 0 and representing a variable expense, is directly proportional to plant activity or income from sales.

The items of indirect expense listed in Fig. 4 should, according to the sales dollar, vary in direct proportion to activity, but physically it is impossible to make them do so, and therefore limits to the amount of variation from the theoretical ideal should be established. At Cheney Brothers, South Manchester, Conn., budgets for 100, 80, 60, 40, 20, and 0 per cent activity were established for each department in the plant. By a careful comparison of actual expenses with the budgeted allowances, and by charting the amount of actual expense for the various departments over a period of about two years, it became possible to establish maximum and minimum limits of variation from the straight-line relationship for the variable indirect expenses. It is obvious that the minimum variation from the directly proportional straight line for various degrees of activity is zero, so that the straight line itself may represent the minimum. Empirically, it has become possible to state that the maximum is the parabola expressed by the equation $Y^2 = KX$. (See Fig. 4.)

In Fig. 4, the distance between the minimum straight line and the maximum parabola is called D. Somewhere between the minimum and maximum is the permissible allowed variation over and above the straight line. This permissible allowed variation is expressed in terms of percentages of D. For instance, the allowed variation from the minimum theoretical straight line for indirect labor is 40 per cent of D, and a curve plotted through points of 40 per cent of D for different percentages of activity represents the expense control curve for this item. For any given weekly activity, the ordinate to the expense control curve represents the standard allowed expense with which the actual for the week is compared. Each foreman is thus furnished with expense reports each week for the items of variable indirect expense he controls, and he must keep his expenses within predetermined authorized variations that, as will be shown later, have been used to modify the break-even chart. His report also shows comparisons of his actual and allowed direct expenses.

It has been possible to apply the standard allowance, 25 per cent of D, for machine repairs, indirect supplies, and miscellaneous expense in practically all production departments. The mill allowance for indirect labor, however, while set at 40 per cent of D for most departments, varies according to local conditions and may be 60 per cent of D in some cases, but in no case is it allowed to exceed 100 per cent of D, which is the parabola. So far, it has not been possible to determine the allowed variation for variable power for the reason that individual departmental meters have not been available.

VARIATION OF FIXED EXPENSES WITH ACTIVITY

There are certain items of "fixed expense" which Professor Rautenstrauch refers to as "constant total costs." According to the control required by the sales dollar, as demonstrated in the discussion of Fig. 2, all expenses, whether classified as fixed or variable, should vary in direct proportion to plant activity. From an examination of Fig. 1, it may readily be seen that the amount of loss due to operating below the break-even point of 71.4 per cent capacity is entirely due to the so-called fixed expenses remaining constant for all degrees of activity. For this reason, it is necessary to examine the whole group of fixed expenses in order to determine which of them may in reality be "semi-fixed."

There are relatively few items of expense which cannot be made to vary to some extent with activity. There are some

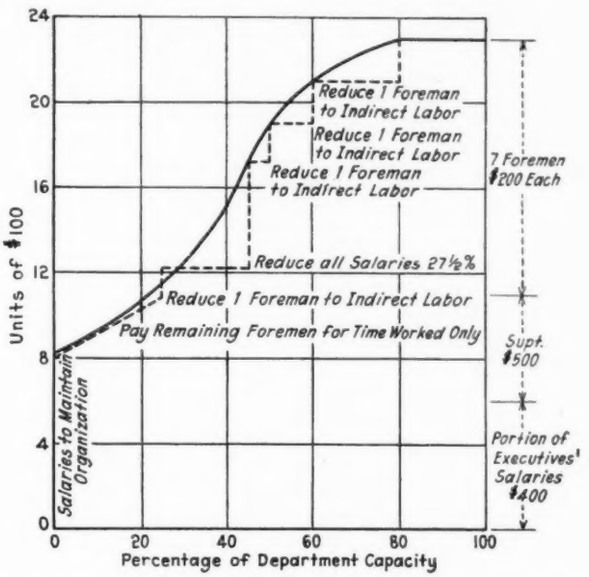


FIG. 5 CONTROL OF SALARIES OF PRODUCTION DEPARTMENT, SHOWING METHOD OF CONTROL FOR SEMI-FIXED EXPENSE

(Portion of executive salaries assigned at normal operation is $400. Executive salaries reduced 27½ per cent at 45 per cent of activity.)

expenses, such as insurance, taxes, rentals of properties where properties are leased, etc., that will not vary with changes in activity and are actually fixed per annum. Such expenses as salaries, stores expense, costing, central planning, etc., while in many instances classified as fixed, may actually be made to vary to some extent with activity. Fig. 5 is a sample chart illustrating the way one of the so-called fixed expenses may be made to vary with activity. At first glance, it may appear to be a very unsatisfactory method of treating salaried employees. On the other hand, it is important to realize the economic justification for the payment of salaries and to control them in a manner that is humane, as well as preserving the best nucleus of an organization for the future, for quite often a failure to plan a method of salary control results in the sudden discharge of a large number of salaried employees with no advance warning. This, however, is a subject in itself, and the chart serves to illustrate one method of controlling a so-called fixed expense and making it vary with activity.

THE MODIFIED BREAK-EVEN CHART

The conventional break-even chart is based on the assumption that all variable expense has a straight-line relationship or is

in direct proportion to activity, and that all the items classed as fixed expense remain as constant fixed expense for the whole range of plant activity.

In Fig. 6, the conventional break-even chart shown in Fig. 1 is designated by the following lines:

(*a*) Theoretical variable cost (dotted line)
(*b*) Theoretical total cost (dotted line)
(*c*) Income.

Since the variable indirect expenses cannot be controlled in a direct straight-line relationship, the dollars of extra allowance for all items of such expense should be added together

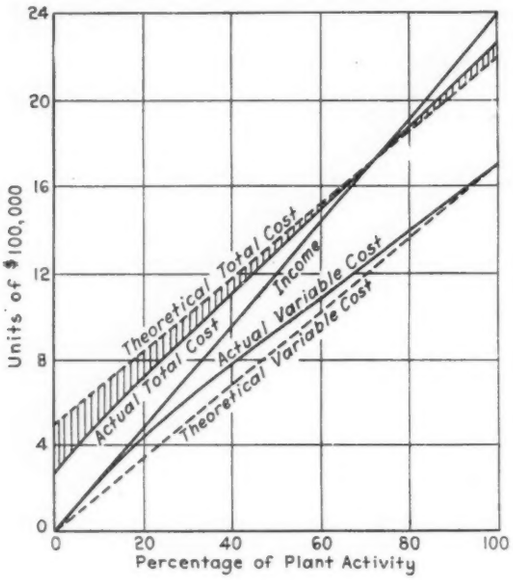


FIG. 6 COMPARISON OF PRACTICAL WORKING CHART WITH THEORETICAL CROSS-OVER CHART

for a given percentage of activity and the extra allowance obtained should then be added to the "theoretical variable cost." In Fig. 6, the line of "actual variable cost" represents the result obtained.

Since some of the fixed expenses are in reality semi-fixed, they may be reduced as sales income and activity decrease. If the amounts authorized for items of fixed and semi-fixed expenses at a given activity are added to the "actual variable cost," the curve of "actual total cost" may be obtained.

The sales dollar used in this discussion to build up a practical working chart was established on the budget of expense and income made at 80 per cent of plant capacity according to the conventional break-even chart shown in Figs. 1 and 2. It is therefore obvious that the "constant total cost" of the conventional break-even chart is equal to the fixed and semi-fixed expense of the practical working chart at 80 per cent activity. Since the "actual variable cost" is arrived at by adding an allowance to the straight line "theoretical variable cost," it may readily be seen that if the same budgeted amounts of fixed and semi-fixed expenses are added to (1) "theoretical variable cost" and (2) "actual variable cost," the line of "actual total cost" will exceed the line of "theoretical total cost" at this point. Since the group of fixed and semi-fixed expenses contain some semi-variable elements that may be made to decrease as activity decreases, these same semi-variable elements increase as activity increases, although not in direct proportion to activity. In Fig. 6, the line of "actual total cost" is shown crossing the line of "theoretical total cost" at some point above the break-even point and gradually increasing as activity increases.

The cross-hatched area of Fig. 6 represents the difference between the theoretical break-even chart and a practical working chart. For example:

At 90 per cent activity, Professor Rautenstrauch's equation $p = X - (a + bX)$, gives a profit of $130,000. In the equation,

p = profit
a = fixed expense, or as Professor Rautenstrauch designates it, "constant total costs"
$b = \dfrac{\text{variable total cost}}{\text{corresponding sales}}$

Based on a curve reading of the "actual total cost" and the "income" line in Fig. 6, the profit at 90 per cent activity is reduced approximately $40,000 by the cross-hatched area, or instead of $130,000, the profit is $90,000.

Similarly, at 30 per cent activity, the same equation indicates a loss of $290,000.

Taking the difference between the "income" line and the "actual total cost," there is a reduction in the loss, according to the cross-hatched area, of approximately $95,000, or instead of $290,000, the loss is $290,000 minus $95,000, or $195,000.

From this comparison, it may be seen that a literal use of the equations is likely to be misleading. This should not detract, however, from the value of the underlying theory expressed by the equations, for an understanding of the laws developed by Professor Rautenstrauch is essential in order properly to control any industry. Each business has its own peculiar economic characteristics and these should be developed and expressed in such a manner that the theoretical chart (Fig. 1) may be modified and put on a practical working basis (see Fig. 6).

SPECIAL ECONOMIC CHARACTERISTICS

The following special economic characteristics develop from a study of the curves:

(1) Direct labor and direct materials should vary in direct proportion to the percentage of plant capacity in a straight-line relationship.

(2) Variable overhead items should be made to vary with activity as closely as possible to the straight-line relationship.

In the silk industry, the variable overhead items may be controlled between the maximum and minimum limits shown in Fig. 4, and according to the equation $Y = p(\sqrt{KX} - bX) + bX$, where p is the percentage of D allowed. The curve for which this equation is the expression may be developed as outlined in the caption of Fig. 4. It is felt that it is better to develop the curve in terms of percentage of D (see Fig. 4), as there is a certain comparative value in saying that in one room the extra allowance for indirect labor is 40 per cent of D, while in another it may be 60 per cent of D. Obviously, the reduction in expense from 60 to 40 per cent of D, if it can be accomplished, results in a saving. This is of great importance in a fashion industry, where activity is likely to fluctuate rapidly.

The value of p, or percentage of D, is a special economic characteristic for each room or burden center and for each class of variable indirect expense.

Whether the variable allowances described will apply to industries other than the silk industry is not definitely known, although the general characteristics of the expense class should be similar.

(3) The fixed expenses should be carefully examined

(*Continued on page 515*)

The FLOW *of* FLUIDS *in* CLOSED CONDUITS

By R. J. S. PIGOTT[1]

THE flow of all kinds of fluids, from liquids, such as heavy oil, light oil, and water, to vapors and gases, such as steam, air, CO_2, flue gas, and illuminating gas, is a subject of considerable importance in engineering design.

Generally, the designer must balance the cost of loss of pressure against the fixed charges in the cost of the piping system. For generations, data on flow, mostly of water, and a considerable quantity on steam and air, have been collected. Latterly, the handling of oil and gas, several fluids used in manufacturing and chemical industries, such as paper pulp, clay and cement slurries, sirup, glue, dyes, thick and thin chemical liquids, gases, such as SO_2 and H_2, and highly superheated steam, has shown that the old empirical formulas based on air or water are unreliable. We are therefore forced to reconsider all data on a more rational basis.

DIMENSIONAL HOMOGENEITY AND DYNAMICAL SIMILARITY

The derivation of the basic form of dimensional relation has been given by Reynolds, Gibson, Lamb, Buckingham, Durand, Michell, and others of authority on the subject. The four principal forms will be, for viscous flow:

$$h = \frac{64\mu lv}{2g\rho d^2} = \frac{4\mu lv}{2g\rho M^2} \quad \ldots\ldots [1]$$

$$\Delta P = \rho h = \frac{64\mu lv}{2gd^2} = \frac{4\mu lv}{2gM^2} \quad \ldots\ldots [2]$$

and for turbulent flow:

$$h = \frac{fl\rho v^2}{2gd} = c\left(\frac{\mu}{dv\rho}\right)^n \frac{l\rho v^2}{2gd} \quad \ldots\ldots [3]$$

$$\Delta P = \rho h = \frac{cl\mu^n \rho^{1-n} v^{2-n}}{d^{1+n}} \quad \ldots\ldots [4]$$

where f = the friction factor, a number
c = a constant
h = head of the fluid under conditions of flow, ft
ΔP = pressure loss, lb per sq ft
Δp = pressure loss, lb per sq in.
l = length, ft
d = diameter, ft
v = mean speed, fps
μ = viscosity, in fps units
ρ = density, lb per cu ft
M = mean hydraulic radius = $d/4$ for circular pipes
n = a value varying from about 0.25 to nearly zero, and depending upon roughness only.

The general forms using M instead of d are employed for all shapes other than circular, such as annular pipes (double pipe coils), square or rectangular ducts, or odd shapes.

Any transformations to non-homogeneous units can be made, such as d in inches, ρ in specific gravity, μ in centipoises, p in inches of water. But the author has come to the conclusion that the fundamental units are safest in the long run.

Almost all flow problems in engineering with water, gasoline, air, gas, and steam lie in the region of turbulent flow; but there are some important ones in the viscous region, i.e., flow of heavy oils in pipe lines, and most of the flow of sirups, slurries, and other thick fluids.

Reduced to the usual values for p in lb per sq in., the formulas become

$$\Delta p = \frac{0.00691\mu lv}{d^2} \quad \ldots\ldots [5]$$

for viscous flow in circular pipes,

$$\Delta p = \frac{0.000432\mu lv}{M^2} \quad \ldots\ldots [6]$$

for viscous flow in pipes of any other shape,

$$\Delta p = \frac{0.000108fl\rho v^2}{d} \quad \ldots\ldots [7]$$

for turbulent flow in circular pipes, and

$$\Delta p = \frac{0.000027fl\rho v^2}{M} \quad \ldots\ldots [8]$$

for turbulent flow in pipes of any other shape.

ROUGHNESS EFFECTS

The one stumbling block in the way of complete rationalization has been the effect of roughness of the conduit walls. It is noted that the value of the friction factor in the turbulent region is

$$f = c\left(\frac{\mu}{dv\rho}\right)^n$$

Experience shows that both the constant c and the exponent n depend upon roughness only. For pipes as nearly dead smooth as we can get them, such as drawn brass or lead, and glass tubes, n has a value of about 0.24. For very rough conduits, such as brick ducts, or badly tuberculated cast-iron pipes, the value of n approaches zero. The variation of c and n will be treated in greater detail later.

OLDER FORMULAS

Darcy's original form was

$$h = \frac{v^2 l}{c^2 d} \quad \ldots\ldots [9]$$

where c was a constant representing roughness. Later the expression was changed to the form

$$h = \frac{v^2 l}{c^2 d}\left(1 + \frac{1}{12d}\right) \quad \ldots\ldots [10]$$

[1] Gulf Refining Company, Pittsburgh, Pa. Mem. A.S.M.E.

Contributed by the Petroleum Division and presented at the National Process Meeting, Buffalo, N. Y., June 6 to 8, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

This was an attempt to allow for the effect of diameter.

Weisbach used

$$h = \frac{flv^2}{2gm} \quad [11]$$

where

$$f = 0.0036 + \frac{0.00429}{\sqrt{v}} \quad [12]$$

and Bazin used

$$f = 0.00294\left(1 + \frac{0.3736}{d}\right) \quad [13]$$

Kutter and Ganguillet adopted

$$f = 64.4\left\{\frac{1 + \left(41.6 + \frac{0.00281\ l}{h}\right)\frac{N}{\sqrt{m}}}{\frac{1.811}{N} + 41.6 + \frac{0.00281\ l}{h}}\right\}^2 \quad [14]$$

in which N is a coefficient depending on roughness. This form is cumbersome to handle, but is the first to attempt a systematic evaluation for roughness.

Hazen and Williams used the form

$$h = \frac{lv^{1.862}}{c^{1.852}d^{1.117}} \quad [15]$$

and change the value of c for differences in roughness. The results agree closely with experiments for cast-iron and rough steel pipe in the somewhat limited range employed for water supply, for which they were specifically intended.

For many years tables based on these formulas have had wide and successful use in their field, but if extended to fluids very different from water, they will give unsatisfactory results.

All of the foregoing formulas neglect density and viscosity, and are dimensionally non-homogeneous.

EXPERIMENTAL MATERIAL

Nearly everybody who has developed a formula has based the derived constants on a small percentage of the total data available. For this reason, there would be variations in the formulated results. In work varying from oils to low-viscosity gas these older forms are nearly worthless. It is a curious fact that the oil-pipe-line companies and the chemical engineers have done more with the dimensional type of formula than any other groups, and they have therefore accomplished much better results.

It appeared to the author that there was a good chance of evaluating the effect of roughness, size, density, and viscosity, if all of the available data were considered in a single study.

A recollation of all such data was therefore undertaken, practically all of the work being done by Mr. Emory Kemler of the author's staff, who prepared a paper[2] for the A.S.M.E. Hydraulic Division which contains a full discussion of the data and methods.

About 10,000 to 12,000 individual tests were studied by Kemler; all those in which the data were noticeably incomplete or subject to doubt were discarded. In the final work, approximately 4000 test points were used, from about 200 separate test series. The data covered brass, lead, tin, glass, steel (both plain and riveted), and tarred and cast-iron pipe; the fluids were brine, water, oil, air, steam, and gas.

[2] "A Study of the Data on the Flow of Fluids in Pipes," by Emory Kemler, Trans. A.S.M.E. (1933), paper no. HYD-55-2.

The information gives a rather clear picture of practically the whole range of commercial materials, and the effect of roughness is quite plainly shown.

CORRELATION OF TESTS

The test data fully plotted showed that the experiments of Stanton and Pannell, Saph and Schoder, and Jakob all agree closely for smooth cold-drawn brass and copper tubing. These groups provide the most precise data from a large number of tests, and make it possible to locate what would be a practically "smooth conduit," having the lowest friction. There are relatively few data at values of $dv\rho/\mu$ higher than 1,000,000, but such evidence as exists shows that the slope of the curve is reduced above 400,000, probably tending to become horizontal. It was found that data for drawn tin, lead, and glass pipe, all substantially dead smooth, yield the same values.

Curve 1 of Fig. 3 is the upper limit of the tests on brass tubing and curve 19 is the lower limit. Curves 2 to 10 are the values for different sizes of new steel pipe, and curves 11 to 18 are for the rougher materials. The variation of test points from the average lines chosen is ±5 per cent for the brass and ±10 per cent for the steel. In the case of cast-iron, both new and old, galvanized, tarred, and riveted steel pipe, the variation is often much greater. The reason is obvious. An inspection of formulas [3] and [4] will show that for the same quantity flow, the pressure loss varies inversely as the fifth power of the diameter, since v varies inversely as the square of the diameter.

In an 8-in. cast-iron pipe, with 0.25 in. of tuberculation or scale inside, the friction factor calculated on the nominal diameter of 8 in. will appear about 50 per cent higher than that calculated on the real mean diameter of $7\frac{1}{2}$ in., at the same roughness. Scale thickness cannot be measured directly, but if we are to comprehend the nature of the variation of friction as affected by roughness, we must eliminate such unsound calculations.

The lower critical point appears to be well fixed at $dv\rho/\mu = 1200$, and the value of the friction factor is 0.054 at that point; the upper critical value is about 2500. Between these two values, the flow may be either viscous or turbulent, depending on whether the flow is decreasing from a turbulent condition toward the viscous region or increasing from viscous flow toward turbulence. In both cases the kind of flow previously subsisting tends to persist. The only safe procedure in calculating a line is to use the turbulent values for f, as they are higher than the viscous values, and may occur at any time in passing through the unstable region.

Several authorities (Stodola, Prandtl, etc.) have pointed out that the friction-factor curves for all kinds of conduit from perfectly smooth to entirely rough, must lie between the values for brass pipe and a constant value (approximately 0.054) for entirely rough pipe. Further, all the lines must converge and pass through the point $f = 0.054$, $dv\rho/\mu = 1200$ (the minimum critical value).

Turbulent flow may begin much lower than the value $dv\rho/\mu = 1200$ and viscous flow may be continued above $dv\rho/\mu = 3000$, but the conditions are entirely abnormal, and the unstable region may be taken as 1200 to 2500 for all engineering cases. Fig. 1 shows the data given by Stodola. Curve 1 corresponds to the minimum value of f for the Stanton and Pannell experiments on smooth brass pipe. The exponent of the expression

$$f = c\left(\frac{\mu}{dv\rho}\right)^n$$

is the slope of the line, having a value of 0.234. Curves 2, 3,

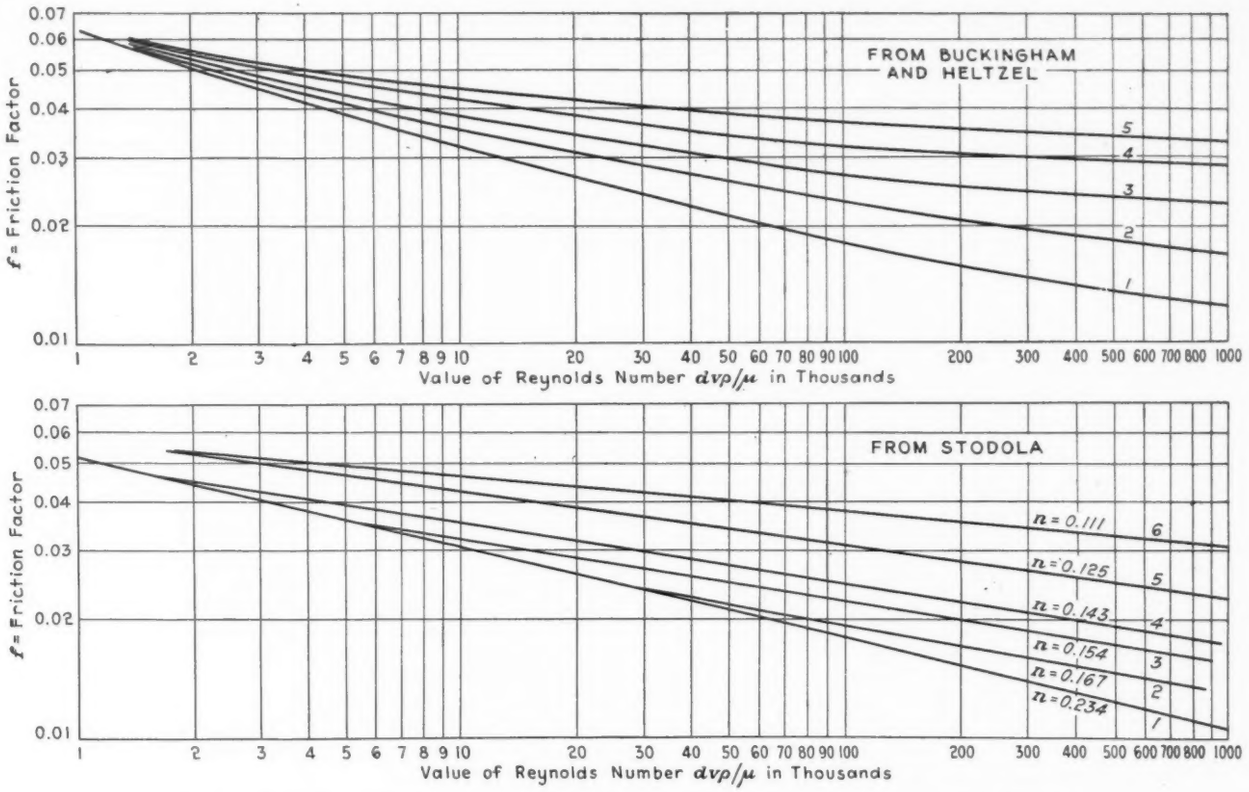


FIG. 1 FRICTION FACTORS FROM BUCKINGHAM AND HELTZEL (ABOVE) AND STODOLA (BELOW)

[Sources of the Buckingham and Heltzel curves are as follows: Curve 1: 8- and 12-in. steel pipe on crude oil (Heltzel); smooth brass pipe (Stanton and Pannell); Curve 2: 3/8-, 3/4-, and 1 1/4-in. steel pipe on steam and water (Lander); 3/4-in. galvanized pipe (Saph and Schoder); Curve 3: 1/2-in. galvanized pipe (Saph and Schoder); Curve 4: 3/8-in. galvanized pipe (Saph and Schoder); Curve 5: 1-in. galvanized pipe (Saph and Schoder).]

etc. are for rougher pipes, with the values of n as noted. It will be noticed that the lines for the smoother sorts of pipe (curves 2, 3, 4) have a flatter slope than those for the dead-smooth pipe and appear to intersect curve 1 at various points. This condition corresponds quite well with the author's, as will be seen from Fig. 1.

Fig. 1 also shows a plot by Heltzel[3] from one made by Edgar Buckingham converted to double-logarithmic, based on some of the Stanton and Pannell, Saph and Schoder, and Lander data, coupled with test results in actual crude-oil pipe lines. This plot also shows the convergence toward a single point at the lower critical condition. The lines are more sharply curved at the low values of $dv\rho/\mu$ near the critical, probably because few of the available data in this region were used.

Hazen and Williams tables give values for brass tube which lie about on the average value for f from Stanton and Pannell. All of the Hazen and Williams data have a constant slope of 0.148 nearly corresponding to that of Kemler's curves for 2- to 6-in. steel pipe. Their method of correcting for roughness by changing c results in a parallel displacement of the f lines, not fanwise; with this method, carried over a large range of $dv\rho/\mu$, the friction factors may be greatly in error. For example, a brick tunnel 6 ft square has about the same roughness as a smooth steel pipe 6-in. in diameter, but the friction factor for the tunnel from Hazen and Williams would be 40 per cent or so higher at the same $dv\rho/\mu$ value. This is because of the assumption that each class of conduit is of the same roughness through a considerable range of diameter; an assumption that is generally far from the truth.

TABLE 1 HAZEN AND WILLIAMS DATA

Curve No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Steel, $c = 120$	...	...	...	...	72, 24	6, 3	3	1	...	...	..	..	..	..	..	..
Best cast iron, $c = 140$	...	...	72, 24	6	3	1	..	..	...	...	..	..	..	..	..	..
Average cast iron, $c = 120$	...	...	...	...	...	...	72	24	6	3	1	..	..	..	..	..
Riveted, $c = 110$	...	...	...	...	...	...	..	..	...	72, 24	6	3	..	..	..	..
Concrete, $c = 120$	...	...	...	...	...	...	..	..	6	...	..	..	..	..	..	..
Brick, $c = 100$	...	...	...	...	...	...	72	24	...	...	72	24, 6	3	..	..	..

The Hazen and Williams values are given in Table 1 for values of $c = 100$ to 140. They assign a value of 130 for brass, implying that it is rougher than the best cast iron, which of course it is not, as a result of the constant-slope values.

Aisenstein[4] replotted some of the data, including the Hazen

[3] "Fluid Flow and Friction in Pipe Lines," by William G. Heltzel, *Oil and Gas Journal*, June 5, 1930.

[4] "Flow in Pipes," by Michael D. Aisenstein, Trans. A.S.M.E. (1929), paper no. HYD-51-7.

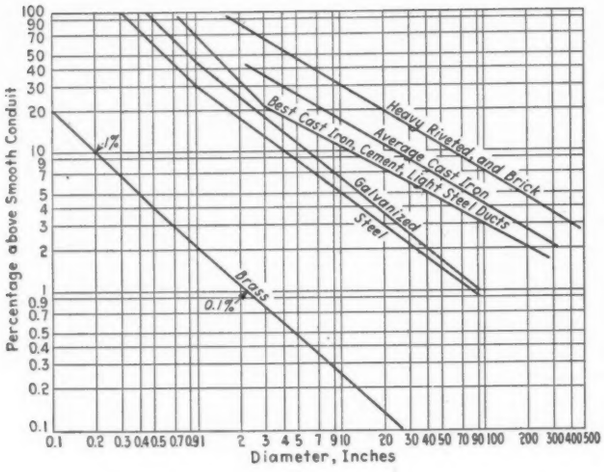


FIG. 2 RELATIVE FRICTION BASED ON FIFTH POWER OF DIAMETER RATIO $\left(\frac{D_1}{D_1 - 2R}\right)$

and Williams values, and then drew an average line at a slope of $n = 0.170$. This method may be convenient for rough and ready calculations but is without any logical basis. Pipe size and consequent roughness are completely disregarded, as are also the perfectly distinct differences of slope for different groups.

EVALUATION OF ROUGHNESS

In so far as the author has been able to discover, no one has developed a complete mathematical analysis of the effect of roughness on the flow, most of our fundamental equations being based on the average velocity and momentum.

To understand the effect of roughness, we should be able to analyze the physical effects so that the velocity traverse could be predicted. About all we know is that the shape is parabolic in viscous flow; for ordinary turbulent flow at moderate values of $dv\rho/\mu$ the shape is roughly elliptical; and for a very high Reynolds number, such as occurs in a metering nozzle for air compressors, it is nearly flat, with only a very slight rounding at the boundary, v decreasing rapidly to zero at the wall. The ratio of average velocity to maximum is 0.5 for viscous flow, 0.76 to 0.92 for ordinary values of the Reynolds number, and may be as high as 0.98 for nozzles at critical speed.

While the task of such an analysis is properly one for a mathematical physicist, the writer made a simple assumption that might conceivably approach the truth. If the roughness of the surface had the effect of entangling a thicker film of fluid at very low speeds near the wall, the result would be much the same as reducing the diameter. Since a change of diameter affects the pressure loss to the fifth power, a small roughness would have a noticeable effect. The same concept has been applied to heat-transfer data with more or less success. The entangled film would be decreased in thickness by increased speed or density, and increased with viscosity and roughness, for the same pipe diameter.

A table of effective diameters and ratios of friction factors was prepared using the average height of projections found in ordinary practice, as a reduction of the radius. The results are given in Fig. 2, showing the percentage by which the friction factor of any conduit should exceed that of a perfectly smooth pipe. Although the roughness was assigned simply from experience with the materials, it is seen that the plots are quite consistent. In order to check the value of the method, Fig. 3 was prepared. The curves 1 to 10 are from tests of steel pipe, and 11 to 18 were arbitrarily selected for the remaining ranges between 10 and the "entirely rough" curve 18 ($f = 0.054$). The values were checked at $dv\rho/\mu = 100{,}000$.

Table 2 shows the results on the friction-factor ratios given in Fig. 2. The results for steel pipe check quite well with test results. For best new cast-iron pipe, the check is fairly good. But in the tests of cement, brick, and riveted pipe, the variation is as much as 2 to 1, and for an obvious reason. The roughness of brick and formed concrete is a matter of workmanship. Well-finished concrete is practically as smooth as the best cast iron in large sizes, but if rough lumber is used for forms, and little care is used in setting forms, the roughness effect may be doubled. The same is true of brick. Hazen and Williams assign a value of $c = 100$ for brick, but in their own references there are tests on this material that show values of 120 to 140, the same as that for cast iron.

The variation in values for riveted pipe is largely due to the pressure for which the line is designed. A light-gage pipe or sheet-steel duct for low air pressure or for a flue will have a relatively smooth surface, but the roughness of a heavy penstock for hydraulic turbines will be four or five times as great because of the effect of the increased thickness of the plates at the lap joints and the size of the rivets. Consequently, the friction-factor tests for a single size will show variations of more than two to one.

If allowance is made for the thickness of the plates, the method discussed here gives fairly satisfactory results. In so far as the author can see, about the only way to assign a position to the friction-factor curves for such pipes is to consider that the values for heavy-pressure riveted pipe will fall fairly close to the position corresponding to the Williams and Hazen $c = 110$ for this kind of pipe, while light-pressure plate-steel air ducts will have values about the same as those of the best cast iron.

It is probable that the film-thickening effect of roughness varies from the zero power of the equivalent diameter ratio at the critical to some power higher than the fifth in the larger Reynolds numbers. But actually, in the ordinary range of $dv\rho/\mu = 20{,}000$ to $600{,}000$, the lines for the smoother types are nearly parallel, particularly for larger sizes; therefore there need be little surprise that the arbitrary assumption of the fifth power checks quite well with the facts available.

For transverse flow in tube nests, such as occurs in condensers, feedwater heaters, boilers, heat exchangers, and similar equipment, the author has found that the friction loss can be accurately calculated on the following basis: The true curved path must be used for length, not the mere linear depth of the tube nest; the mean hydraulic radius is that based on the radial space between tubes; entry loss must be disregarded, as the tubes give the effect of having a fully faired entrance; entrance velocity must be taken into account as part of the available energy for flow; the friction factor is 0.054, as for a fully rough passage. The true path for the usual equilateral tube spacing is 21 per cent greater than the linear depth of the nest. The fully rough condition applies to all cases with diameter from $\frac{1}{2}$ in. to 4 in., as the spacing practically never exceeds one tube diameter, and generally is not more than 0.6 diameter.

Some of the author's laboratory work on the flow of fluids in porous materials, such as sand, suggested the check previously mentioned, and apparently it works satisfactorily. A somewhat more difficult problem was also successfully carried through by the same process. This was for several large condensers on which test data were available as to steam, water, and pressure drop. The calculation is greatly complicated by the change of flow due to condensation, and also by the fact

TABLE 2 SELECTED LOCATION OF f BY ROUGHNESS RELATION

Curve.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Roughness, per cent...	0.2	0.45	0.81	1.35	2.1	3.0	3.8	4.8	6.0	7.2	10.5	14.5	19.0	24.0	28.0	31.5	34.0	37.5
A.....	0.35 up	....	....	....	....	....	....	....	..	..	..	..	..	0.125	..	..	..	0.0625
B.....	72	48 to 66	14 to 42	6 to 12	4 to 5	2 to 3	$1^1/_2$	1 to $1^1/_4$	$^3/_4$	$^1/_2$	$^3/_8$	$^1/_4$	$^1/_8$	....	..	..	..	....
C.....	....	....	30	10 to 24	6 to 8	3 to 5	$2^1/_2$	$1^1/_2$ to 2	$1^1/_4$	1	$^3/_4$	$^1/_2$	..	$^3/_8$	..	$^1/_4$	..	$^1/_8$
D.....	....	....	48 to 96	20 to 48	12 to 16	5 to 10	3 to 4	2 to $2^1/_2$	$1^1/_2$	$1^1/_4$	1	..	..	....	..	..	..	....
E.....	....	....	96	42 to 96	24 to 36	10 to 20	6 to 8	4 to 5	3	..	..	..	..	....	..	..	..	....
F.....	....	....	220	84 to 204	48 to 72	20 to 42	16 to 18	10 to 14	8	5	4	3	..	....	..	..	..	....

A = Drawn tubing, brass, tin, lead, glass, diam., in. B = Clean steel, wrought iron, diam., in. C = Clean, galvanized, diam., in. D = Best cast iron, cement, light riveted sheet ducts, diam., in. E = Average cast iron, rough-formed concrete, diam., in. F = First-class brick, heavy riveted, spiral riveted, diam., in. In drawn tubing, actual inside diameter is given. In pipe, nominal size of standard weight is given.

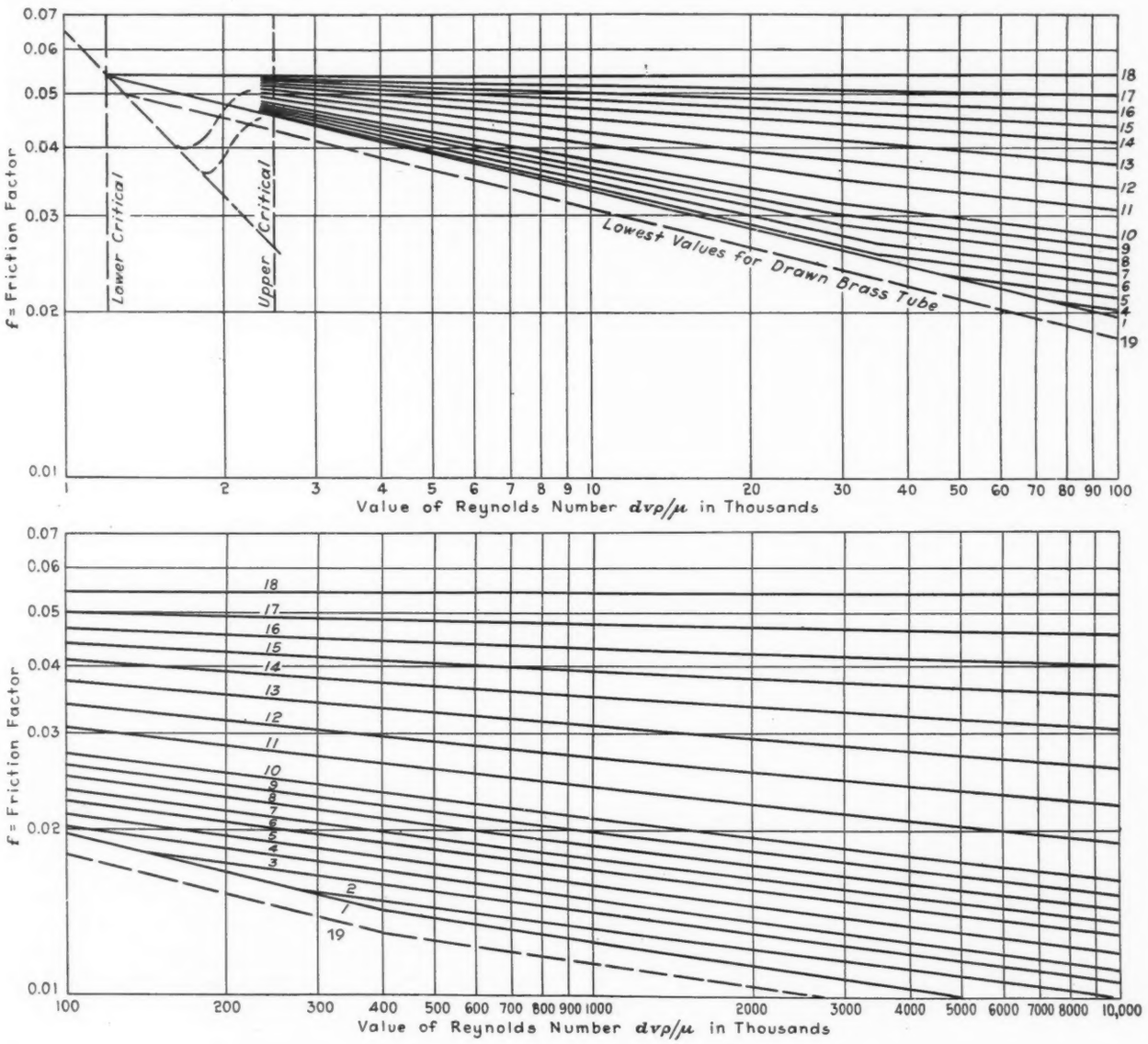

f = Friction Factor
Lower Critical
Upper Critical
Lowest Values for Drawn Brass Tube
Value of Reynolds Number dvρ/μ in Thousands
f = Friction Factor
Value of Reynolds Number dvρ/μ in Thousands

FIG. 3 FRICTION FACTORS (SEE TABLE 2)

$$\Delta p = \frac{0.000108\, flpv^2}{d}$$ for circular pipes

$$\Delta p = \frac{0.000027\, flpv^2}{M}$$ for any shape

that several sizes of tubes at different spacing were employed, and the entry velocity was quite high. The condensers were divided into suitable sections and a first trial heat balance was made to get condensation in each section, in order to establish the flows. Allowing for entry velocities, the pressure drops were calculated section by section; the total drop so obtained checked with test results over varying load within ±10 per cent.

(*Continued on page 515*)

MECHANICAL ENGINEERING

Vol. 55 AUGUST, 1933 No. 8

GEORGE A. STETSON, *Editor*

Engineers and Chicago

A CONSIDERABLE portion of this issue is devoted to addresses given at Chicago during Engineering Week at A Century of Progress Exposition, and to a brief report of some of the activities at the Semi-Annual Meeting of The American Society of Mechanical Engineers.

The Chicago exposition should mean more to engineers than to most persons. The reason does not lie in the fact that the serious side of this great "fair" is essentially a glorification of applied science and industrial progress, but in the more significant fact that it should stimulate, in the minds of the thousands who daily are inspecting its exhibits, a desire to improve individual standards of living and to experience the benefits that are to be derived from countless developments in industrial progress. To know that there exist so many unimagined devices that ease the mechanics of living is to arouse the determination to acquire them.

There is a tremendous store of wealth in this country—natural and physical resources, money, plant and equipment, imagination and creative desire, ambition, and the will to attain innumerable individual satisfactions. It is the coordination of these elements that brings prosperous times. People are going away from Chicago with whetted appetites and aroused imaginations. Engineers will soon have something to do in satisfying their demands.

Expositions and Museums

AS a post-depression activity, there is much to be said for the establishment and expansion of museums of science and industry. A Century of Progress Exposition at Chicago is demonstrating this fact. From all over the United States, all classes of well and indifferently educated persons have found the exhibits in the Hall of Science, and others that were designed with a similar educational objective in mind, stimulating and enlightening. If persons of influence, seeing these exhibits and pondering their significance, return to their several communities with the conviction that similar educational displays should be arranged in some local school or museum for the benefit of old and young, the present exposition at Chicago will have served a highly useful purpose, and will have justified the great amount of time and money it has cost.

So many times has the thought been expressed recently that it seems almost trite to mention once more the belief that citizens of a modern age need a more profound and intimate knowledge of the fundamental sciences without which our civilization could not exist for a single hour. The generation over forty views science less realistically than do the young people still at school, who are exposed to a considerable amount of it in their recreations, their classrooms, and their homes, with the result of being more familiar with it and better acclimated to the social atmosphere it has created. Older persons, in whose experiences tradition and progress are clashing dangerously, are perhaps, more bewildered.

But young and old alike are inadequately adjusted to the rate of scientific progress, and both are faced with the necessity of adaptation as a result of the social, economic, and political evolution that is going on about them at an accelerating rate. A knowledge of the principles of science and the pseudo-sciences in their many branches is the starting point of an understanding of the application of these principles in daily life, of the development of the physical, economic, and social machinery in which these principles play their parts, and of the effect on individual lives and human institutions that inevitably result.

Therefore, let our plea be for more exhibits through which our people may become acquainted with these facts and become conscious of the great forces that are developing their culture. Let them be displayed in museums, like those in Chicago at the Exposition and more permanently at the museum of science and industry that is housed in the reconstructed fire-arts building of the World's Columbian Exposition of forty years ago, in the new museum in Philadelphia, and in the New York Museum of Science and Industry. The springing up of such institutions in centers of population throughout the country would provide a glorious harvest from the seed planted at A Century of Progress Exposition.

Research in Railroading

ACCUSING the railroads of lack of progressiveness has become one of those popular pastimes that almost every one has indulged in, regardless of his knowledge or fitness to be intelligently critical. During Engineering Week in Chicago, under the auspices of the A.S.M.E. Railroad Division, an impressive group of papers on research and developments in railway mechanical engineering recorded a history of progress in this field with which only a few closely connected with it are familiar. These papers will serve as a partial answer to critics of the railroads.

One of the speakers, Samuel O. Dunn, editor of *Railway Age*, called attention to the part played by the supply industries by asking if it seemed probable that a great electrical or steel industry which manufactured for both the automobile and the railroad industries would show great initiative and resourcefulness in contributing to the progress of one, and a conspicuous lack of it in contributing to the progress of the other. To ask the

question is to answer it, and perhaps, to throw the blame on the managers and engineers of the railroads, and to accuse them of lack of fertility. Mr. Dunn's paper, and those of the other contributors, demonstrated that this was not always the case. These developments, however, are, in general, not of the spectacular nature that catch public fancy, nor have they been given such publicity. Certainly, the locomotives and railway equipment on display at the Exposition bear evidence of fertility of mind, and demonstrate that the railroads make use of the changes in design, methods, and materials that progress in other industries has developed.

But most impressive is the record of the railroads with regard to safety. Last year, not a single revenue passenger lost his life in a train accident in a total of nearly seventeen billion miles traveled. Back of this performance are the developments in hundreds of materials and accessories to railroading, and the rigid discipline of personnel in manufacture, inspection, operation, and maintenance that results in eternal vigilance. The competitors of the railroads should match this record before becoming too critical of the lack of what can easily be change only for the sake of change. Safety and reliability are prime requisites in railroading, and novelties that may affect either will never be welcomed without critical suspicion by men competent to run a railroad.

That the universities and the manufacturers have made their contributions to railroad research was amply brought out in the papers. In many cases, the advantages of cooperative research were convincingly displayed. The American Railway Association, Mechanical Division, and numerous trade associations among the manufacturers have a long and commendable record in cooperative research at the universities, particularly Purdue and the University of Illinois, as was brought out at the meeting.

The value of cooperative research is not to be denied. C. D. Young, vice-president, Pennsylvania Railroad, called attention to a statement by Joseph B. Eastman, Federal Coordinator of Transportation, on the desirability of a central agency, acting for the railroads, that should include provision for a highly organized central research department. Endorsing this view, Colonel Young called for a Director of Research, under the jurisdiction of the executives of the American Railway Association, whose duties should be "to coordinate all research activities of all divisions and bureaus, plan the work to be done, allocate and direct where it should be conducted, decide sequences of activity, and in general to pursue many inquiries which at present are difficult, owing to the competitive conditions between railroads themselves and other modes of transportation."

If the meeting at Chicago should lead to the setting up of such an agency of coordination in railroad research, it will have accomplished much more than merely telling the world that the railroads are not as backward as they have been accused of being. Transportation is too essential a factor in national life to be denied the very greatest benefits that research and human intelligence can bring to it. Under the stimulus of the meeting in Chicago, of which the A.S.M.E. Railroad Division can be justly proud, research in railroading should go forward with renewed zeal and with closer cooperation and coordination. If the railroads do this, criticisms of lack of progress will quickly disappear.

Public Services of Engineers

A GROWING appreciation of the public services of engineers is evident on all sides. Several speakers at Chicago, in particular, those who contributed to the sessions devoted to econometrics and engineering, and those who addressed the banquet on Engineers' Day, emphasized the opportunities and obligations that lie in this field. The social and political conditions that give rise to the need for engineers in the solution of problems of public interest are described in an article in this issue by William Beard. Recent changes in the functions of the Administration at Washington, illustrated by the National Industrial Recovery Act, demonstrate further the importance of engineering in national planning and well-being. Specifically, the appointment of many engineers in administrative and consultative capacities, including that of Arthur E. Morgan as head of the Tennessee Valley Authority, is an indication of a growing tendency to enlist professional talent in public causes.

But engineers who enter this fascinating and lively field of public service must realize that many of their dealings are likely to be with politicians whose methods may lack the impersonal and academic quality of engineering and scientific contacts. This was shockingly displayed at a joint meeting of the A.S.M.E., the A.S.C.E., and the A.I.E.E., in Chicago, when an attack was made on the integrity of Prof. Daniel W. Mead, professor of hydraulics at the University of Wisconsin, who had prepared a critical study of the economic and financial factors involved in the various plans proposed for the development of the International Section of the St. Lawrence River.

Undoubtedly, engineers who interest themselves in the public service, or in the discussion of subjects that have become politically controversial, must expect attacks on their characters and motives such as that made on Professor Mead. The public loses much valuable service because engineers do not wish to subject themselves to the rough and tumble of political debate and personal attack. Dr. Morgan, in taking over his duties with the Tennessee Valley Authority, took the precaution of listing with Secretary of State Hull his personal holdings and those of his immediate family, and announced his intention of filing a similar list at the end of his period of service. This unusual and somewhat dramatic precaution is an indication of a realization of some of the hazards of the office. Dr. Morgan's action and the attack on Professor Mead called the attention of engineers to some of the unpleasant factors that are incidents of public service.

SURVEY OF ENGINEERING PROGRESS

A Review af Attainment in Mechanical Engineering and Related Fields

APPLIED MECHANICS

What Is Weight?

THIS problem has been raised by the German Board of Units and Magnitudes in Equations (Ausschuss für Einheiten und Formelgrössen, also known as AEF). The original definition of weight adopted by the board some ten years ago was that it was a force. Certain objections have been raised to this definition, and it would appear that there are now three conceptions of weight. The adherents of what might be called view *A* lay the stress on the fact that mass is determined on a scale by a comparison with predetermined "weights." Under this view, weight is the result of weighing and has the same meaning as mass. Adherents of this view bear in mind, however, that in science or engineering, the word weight is often used in the sense of the force of gravity or of the pressure produced on the underside of the body. They draw from this the conclusion that the word weight, having acquired two different meanings, should not be used in scientific language and should be replaced on one hand by the word mass, and on the other by the expression "force of weight."

The adherents of view *B* start likewise from the premise that historically, and because of common usage, weight has acquired the meaning, "result of weighing." Weighing may compare two bodies (1) with respect to their gravitational force, and (2) with respect to their masses, provided, however, as to the latter, that the acceleration due to gravity in the region of the location of the scale is constant. The first of these principles of comparison is a primary one, while the second is based on the fact that mass is independent of the place and time of weighing. It is because of this and because of the fact that the mass of a substance is proportional to its quantity that weighing may be used for determining the quantity. It is in this way that the law, the daily life, and a portion of science, such as chemistry, understand the word weight. It would be better, however, to define it as "the comparative value obtained by weighing."

In accordance as the standard weight piece represents either mass or a force, the weight itself can be considered either as a mass or as a force. We must therefore distinguish between weight-mass and weight-force.

Group *C* holds the view that the usage does not compel us to understand the words weight and "results of weighing" as being the same things. Weight in scientific knowledge has for a long time been understood to mean the force of pressure produced on the underside of a body by gravity. When the word weight is used in places where the determination of a mass by weighing is meant, this is merely a somewhat careless practise of expression, which, however, only seldom led to a real misunderstanding. The adherents of this view claimed that it was the business of the Board (AEF) to provide a clear distinction between the concepts of mass and weight entirely different from each other. They have no objection, however, to the use of the word weight to determine the standard basis by which weighing is accomplished.

It will be noted that the adherents of views *A* and *C* avoid the use of the word "quantity." This does not imply, however, that in their views the idea of quantity is superfluous or identical with the idea of mass. They prefer, however, to eliminate as many controversial points as possible.

The following example is cited in illustration of these three views:

Let it be assumed that naphthalene is being weighed at room temperature with a brass weight of 10 grams on a scale with the fulcrum in the middle. Let it be further assumed that the acceleration due to gravity at the place of weighing is 981.4 cm per sec per sec.

The adherents of the three views cited above claim, then, as follows:

View *A*. The mass of the naphthalene amounts, without correction, to 10 grams, and after correction (that is reduced to terms of vacuum) to 10.009 grams, while the force of gravity acting on it is 98.23 dynes, equal to 10.017 grams of force.

View *B*. The uncorrected weight of the naphthalene is 10 and the corrected weight 10.009. The weight mass is 10.009 grams and the gravitational force 98.23 dynes equal to 10.017 grams of force.

View *C*. The uncorrected result of weighing is 10 grams. The mass of naphthalene is 10.009 grams and its weight is 98.23 dynes, equal to 10.017 grams of force. The Board, located at Bismarckstrasse 33, Berlin-Charlottenberg 4, Germany, requests an expression of opinion as to the three views stated above. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 77, no. 23, June 10, 1933, p. 622, *cg*)

Production of Vibrations by Solid Carbon Dioxide

IF A solid block of carbon dioxide is held against a metal, a rattling or singing sound due to vibrations of the latter will often be heard. The observations were made on bodies of various shapes, masses, and materials, including tuning forks with a range of frequencies of 100 to 10,000 cycles, brass bars with a range of frequencies of 1950 to 15,000 cycles, steel bars, and other materials.

It was noticed that the ease with which vibrations could be excited varied from day to day, and that when a fork was being excited, water sometimes condensed on it near the point of contact with the carbon dioxide block, presumably due to cooling of air below the dew point. It has been found, however, that the changes in weather were not responsible for the differences in the results obtained on different days.

The physical properties desirable in the body to be set into vibration in this manner are a suitable natural period of vibration, high thermal conductivity and elasticity, a small damping factor, and hardness, and for maintaining vibrations in small bodies of a given size, high specific heat and specific gravity.

There is some evidence of selectivity in the range of frequencies best excited by various blocks. Certain applications of this method have been suggested, such as oxidation of stout forks of frequencies ranging from 2000 to 6000 cycles. They are not easy to excite electrically, but if excited by solid carbon dioxide, loud notes may be maintained for a minute or so,

setting into vibration the metal objects which cannot be excited by hammering, bowing, or electrical methods. The recognition and accentuation of overtones may sometimes be of value to the engineer in discovering undesirable resonances in small pieces of machinery or in electrical plate condensers.

Solid carbon dioxide which has been prepared by freezing, and which is free of oil, may be considered to have standard properties in producing vibrations. With such a block, more or less noise may be produced by contact with solid substances which are semi-conductors, as, for example, quartz, marble, and other stones; and it is only in substances with high insulating properties, such as sealing-wax, ebonite, amber, or cork, that no sound whatsoever can be detected. These facts may be of interest to the geologist. Again, quartz lenses can be immediately distinguished from glass lenses by bringing them into contact with solid carbon dioxide.

If mercury is progressively cooled by contact with solid carbon dioxide, dew eventually forms on the surface. The dew forms suddenly, but owing to the ripples it appears far below the dew point. Thus on a warm damp day, when the room temperature was 68 F, dew only appeared at 37 F, but then appeared copiously. On the other hand, when the block was removed at the right moment, leaving the surface still, dew formed at 60 F, as compared with 59 F on the surface of a polished calorimeter containing water to which pieces of ice were added. Thus, were it not for the ripples, mercury would offer an excellent polished surface for dew-point determinations, and solid carbon dioxide an easy method of cooling it. There might also be objections, however, from the point of view of hygrometry, to the presence of carbon-dioxide gas. (Mary D. Waller. Paper read before the Physical Society, abstracted through *Ice and Cold Storage*, vol. 36, no. 422, May, 1933, p. 82, *e*)

ENGINEERING MATERIALS (See also Special Processes: Synthetic Rubber in Russia)

Sherrite Steel Sheets

MR. SHERARD COWPER-COLES, the inventor of the sherardizing process, has now developed a process for the electrodeposition of zinc on steel plates and has evolved a continuous automatic machine which it is claimed can coat standard-size sheets at the rate of several a minute. In the simplest form, the apparatus consists of a bath of electrolyte through which the sheet constituting the cathode is passed several times until the deposit is of the required thickness. The anodes, in the form of bars, are placed across the top of the bath and dip into the electrolyte. The sheet is propelled by electrically driven rollers through the bath of electrolyte below the anodes. Continuous automatic plants consist of a train of baths and vats, the sheets being fed at one end and propelled by means of rollers and guides, first, into a pickling vat, then into a washing bath, and then into one or more depositing baths. It is said that the coated product possesses a uniform matt and gray surface which, it is claimed, does not rust even at a cut raw edge. When the sheets are used for motor-car bodies, mud guards, etc., no first or priming coat is necessary and rust will not creep below the coat of enamel. Mainly on account of the much lower price of zinc as compared with tin, it is claimed that the new plates can be produced at a cost considerably lower than tin plate. The process has been extended to the coating of steel sheets with brass and copper. The same apparatus as for zinc coating is used but with different anodes and electrolytes. (*Engineering*, vol. 135, no. 3515, May 26, 1933, p. 584, *d*)

FUELS AND FIRING (See also Internal-Combustion Engineering: Relation of Lubricant and Fuel to Carbon Formation With Special Reference to Gum)

Bituminous Coal Tar as Fuel for Diesel Locomotives Underground

WHILE the title of the article appears to limit discussion of the subject to the mining field, the article itself treats the subject in a far more general manner. It points out to start with that the consumption of petroleum per person is 572 kg in America and 25 kg in Germany, showing that should more extensive motorization of equipment take place in the latter country, there will be an extension of a demand for fuels. The author believes that fuels obtained from coal can be used in Diesel engines and that eventually even the State Railways may motorize their passenger traffic. There are already 78 Diesel-engined cars on German railroads and 62 more are under order. The author states that experience has shown that it is impossible, without preliminary preparation, to pass from the operation of Diesel engines on gas oil to operation on tar oil. The reason for this lies in the different structure of the fuels, and in the difference in their heat value, the amount of air required for their consumption, and their temperatures of ignition.

From the point of view of chemical composition and physical structure, it is pointed out that the products of coal-tar treatment are light oil, medium oil, heavy oil, anthracene oil, and pitch. The tar oils used in Diesel engines consist either of a mixture of heavy oils with anthracene oils or heavy oils with medium oils. All Diesel-engine oils should have the characteristic that when injected into the combustion chamber they will evaporate at high temperatures only and will not ignite below the temperature of evaporation. They will have this characteristic if they have been distilled at a temperature in excess of 230 C (446 F). The portions boiling above 350 C (662 F) should not be present, as they retard combustion; neither should constituents boiling below 230 C be present, as they are apt to produce knocking because of excessively violent combustion. The author gives a table showing the comparative heat values of gas oil, lignite-tar oil and bituminous-tar oil, as well as their chemical compositions. A striking feature is that the content of hydrogen in gas oil (13 per cent) is nearly twice as great as in tar oil (7 per cent) and he claims that it is this feature that makes gas oils particularly suitable for the Diesel process, on account of the fact that a high hydrogen content promotes ignition. The ignition temperature of hydrogen gas lies between 580 and 590 C (1076 and 1094 F), whereas carbon monoxide, which is produced in large quantities from tar oil, ignites only at temperatures of 650 to 660 C (1202 to 1220 F). Methane gas, which is also produced in large quantities from tar oil, ignites at still higher temperatures, 650 to 750 C (1202 to 1382 F).

The specific weight of gas oil (0.85) is lower than that of tar oil (1.08), and since specific weight may be considered as a rough measure of combustibility of Diesel oils, this would again indicate that tar oil is more difficult to burn. The viscosity of tar oil is also materially higher than that of gas oil.

As regards conditions for operation on tar oil as compared with those on gas oil, it is stated that, in general, in order to produce a certain horsepower output, the fuel must provide a predetermined amount of heat. The fuel required must be mixed with the predetermined amount of air to produce complete combustion, and ignitibility of the fuel must be made possible by raising the mass to a certain temperature created in the engine by the compression of the air.

As regards the amount of fuel required, it is stated that the

consumption is in the ratio of 212 to 235, or 0.90, in favor of tar oil when measured by volume. On the other hand, tar oil requires theoretically about 5 per cent more air for complete combustion than does gas oil. It is stated, however, that in so far as the matter of supply of air is concerned, a Diesel engine set for gas oil will operate perfectly well with tar oil, because of the fact that all Diesel engines operate with a considerable excess of air. The author gives a numerical example in which he calculates the amount of air actually consumed, and finds that the ordinary Diesel engine consumes 1.68 times as much air as is theoretically necessary, while in some cases the consumption of air may be still greater. This part of the article is not completely abstracted.

The author gives a table of final compression temperatures for various compression pressures under the assumption of two different suction temperatures. Tests have shown that the ignition temperatures for gas oils, determined in oxygen, are 240 to 275 C (464 to 527 F), and for tar oils, 470 to 520 C (878 to 968 F).

The author shows that in the case of tar oils having a self-ignition temperature of 490 C (914 F), an air temperature in the engine of 740 C (1364 F) would be required. Extensive tests along this line have been carried out on a compressorless Diesel engine built by the Germania Works at Kiel by the Association of Sellers of Tar Products (Verkaufsvereinigung für Teererzeugnisse, Essen).

When the compression pressure was raised to 40 atm, the motor ran with tar oil under full load and with normal suction temperature of 27 C (80.6 F). At half load it was necessary to preheat the air to 50 C (122 F); at a quarter load, to 60 C (140 F); and at no load, to 110 (230 F).

By calculating the end temperature of the air at a suction temperature of 110 C (230 F), under the assumption of a polytropic compression, one obtains

$$T_2 = T_1 \left(\frac{p_2}{p_1}\right)^{0.278} = 1070 \text{ C (abs)}$$

hence $t_2 = 797$ C (1467 F)

This means that with a self-ignition temperature of tar oils of 500 C (932 F), the air temperature in the motor was practically 297 C (567 F) higher. Since a vehicle motor may frequently have to operate at no load, it is necessary to provide ignitibility under those conditions. This temperature was obtained without any preheating, but with a compression end pressure of 60 atm, that is, double that now common. This would indicate that it is impossible to convert a Diesel engine designed for gas oil into one operating on tar oil without a certain amount of rebuilding. The use of end pressures of such a magnitude as 60 atm in locomotive service is out of the question, as they require enormous increases in the sizes and strength of machine parts.

In stationary engines, a roundabout way was adopted. Designers ceased relying on the generation of high temperatures by means of compression and introduced an artificial flame into the combustion chamber, as, for example, by the injection of a few drops of gas oil. Several of the largest German concerns have been using this and obtaining good results. The "igniting" gas oil amounts to about 5 per cent of the maximum consumption of the tar oil and is applied without regulation of its quantity. It provides an absolutely certain method of ignition which can be used in starting the engine from cold and does not require the operation on the main fuel pump with gas oil.

While this works well with stationary engines, in locomotive engines, because of their small dimensions, the amount of igniting fuel to be injected becomes too small to permit convenient handling.

It would appear, therefore, that in changing a Diesel engine from gas oil to tar oil, no trouble need be experienced in respect to supply of heat through the fuel pump and air consumption required for combustion. The output with tar oil is actually better, and with the same pump delivery, the engine output is about 11 per cent greater than with gas oil, or for the same output, it shows a fuel economy of 10 per cent.

To obtain these advantages, however, the difficulties of ignition must be overcome. Ignition of the fog of fuel in the highly heated air requires time. This phenomenon is generally referred to as the ignition lag. The shorter this lag the more certainly ignition throughout the whole mixture takes place, and Hawkes (*Engineering*, 1920, p. 749) showed that the ignition lag decreases in proportion to the increase of the temperature difference between the hot air and the temperature of self-ignition of the working oil. Hawkes showed that at 350 C (662 F), the ignition lag is 0.08 sec and at 360 C (680 F) 0.04 sec. In the case of a locomotive Diesel engine running at 1000 rpm and operating the injection during a crank angle of 30 deg, only 0.005 sec is available for purposes of ignition, which would indicate that even in the case of gas oil temperatures of 500 to 600 C (932 to 1112 F) are necessary.

High temperature differences favor the transfer of heat through conduction, and it is by heat conduction that the fuel injected into an engine gets its ignition heat from the hot air. If an attempt is made to calculate the coefficients of heat transfer which must be present, considering the short time available for ignition, extraordinarily high and entirely improbable values are arrived at. Neumann concludes from this that the rapid rise of temperature preceding ignition must be due to some chemical reaction, and this leads the author to proceed to the discussion of chemical factors affecting the processes of ignition and their use for combating the difficulties of ignition.

The fog of droplets of fuel floating in the hot air is evaporated at the high temperature prevailing and becomes surrounded by a gaseous shell which at first consists of the lightest hydrocarbons. Under the influence of the high temperature of the combustion space, these hydrocarbons lose hydrogen atoms and thereby become unsaturated. This unsaturated gas envelope of the hydrocarbon particles eagerly takes up oxygen from the hot air, which results in building up peroxides. This adsorption of oxygen particles produces an extraordinarily powerful generation of heat known as heat of reaction, increasing the velocity of oxidation and a sudden breaking down of the oxides thus formed, resulting in ignition. In chemical language, ignition would seem to depend on the presence of a high velocity of oxidation persisting until a sudden breakdown of oxygen compounds takes place.

Neumann claims to have shown that the ignition lag is 3.1 times as great when chemical heat of reaction is not present. The ignition lag produced by heat conduction alone amounted to 0.0062 sec and fell off to 0.0020 sec under the action of the chemical reaction. He also showed that the amount of oxygen necessary to produce ignition is 2.73 times as great as the amount necessary for subsequent combustion, which means that if ignition has been started somewhere, the combustion of the entire mass follows with increasing velocity. From this it would appear that the temperature of the air in the combustion chamber and this concentration of oxygen are needed at one point only of the combustion space, namely, where ignition should take place. This means that the designer must do his best to eliminate any influences that would oppose propagation of chemical reaction at a given place in the combustion chamber, from which it follows that

an attempt must be made to increase the affinity between the oxygen of the air and the fuel at one place only. This can be done by employing a catalytic agent, platinum sponge, for example, in the stream of gas, where its presence produces ignition of the mass by an increase in the velocity of oxidation, assisted by a concentration of oxygen.

Recent tests along these lines have confirmed the previously existing theory. Thus, Broche used platinized asbestos as an oxidation catalyst and measured the ignition temperatures with and without the catalyst. He found the ignition temperature with American gas oil to be 248 C (478.4 F) without a catalyst and 95 C (203 F) with it, and on coke tar oil, 470 C (878 F) without and 180 C (356 F) with the catalyst.

It has also been found that with the ignition point of the tar oil so lowered by means of a catalyst, there were no ignition troubles in passing from operation on gas oil to operation on tar oil. According to the author's observations, the temperature of the combustion chamber must be about 250 C (482 F) above the ignition temperature of the fuel in order to give good performance, which means that in the case of tar oil the temperature of the combustion chamber should be 180 + 250 = 430 C (806 F), which can be attained with the usual compression end pressure of 30 atm.

Tests on a Diesel engine confirmed the correctness of these observations. Broche used for his tests a Deutz Diesel engine working with a precombustion chamber, as shown diagrammatically in Fig. 1. The contact body *k* is located in the precombustion chamber *v* and is provided with an umbrella-like tip against which the jet from the fuel nozzle *d* is directed. Initially, this steel umbrella was provided to protect the contact substance. Notwithstanding this protection, the contact substance was rapidly destroyed, but it was found that the steel plug in itself acted sufficiently well as a contact body. The contact body must be in a state of glow and must be therefore of sufficiently large mass to provide a reservoir of heat that would keep it in a state of glow from cycle to cycle. On the other hand, the steel body must not be too large, so as not to reduce excessively the air capacity of the precombustion chamber. Because of the necessity of providing a material free from corrosion, special steels have to be used in the contact plug, and inorganic materials, such as "silit" and carborundum, also appear to be suitable. The test showed that when the engine was shifted to tar oil, it worked faultlessly. Failure of ignition, smoky exhaust, and knocking disappeared, and the motor worked as smoothly as with gas oil.

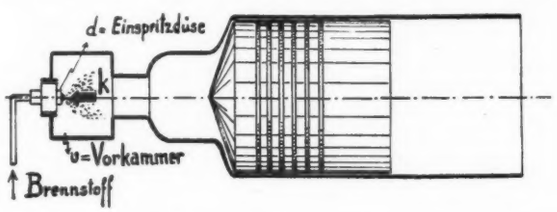


FIG. 1 DEUTZ DIESEL ENGINE WITH A CATALYZER CONTACT BODY IN THE PRECOMBUSTION CHAMBER

(*d* = injection nozzle; *v* = precombustion chamber; *Brennstoff* = fuel.)

As the platinized contact substance has now been eliminated and only the metallic zone of glow provided, the question arises as to just how ignition originates; i.e., by the heat of chemical reaction or by improved heat storage. This is not yet clear, particularly as it has been found that the motor tug *Bulldog*, built by the Lanz Machine Co., and employing an externally heated hot bulb, also works well on tar oil, yet no one would consider the hot bulb as performing the functions of a contact body. Similar and independent tests have been carried out by the Benzol Association and the Tar Products Sales Association, using a machine of the same type as that used by Broche. They found that with the hot body in the precombustion chamber they could obtain excellent results with tar, providing the motor was warm. To start from cold, however, outside ignition became necessary. As such an ignition device, a saltpeter paper cartridge, inserted into the precombustion chamber and set on fire previous to starting the engine, has been used. This is said to have been sufficient for starting the small engine by hand cranking.

The author next discusses the elimination of ignition troubles by means of mixture of fuels, as well as various ways of eliminating ignition difficulties by means of outside ignition. This can be done by reducing the degree of compression in the Diesel engine and using spark-plug ignition in a manner substantially similar to that used in gasoline engines. The author describes the Thomas-Stuhr engine, in which the volumetric compression ratio is only one to ten, resulting in a compression of about 20 atm. Contrary to previous apprehension, there has been no trouble with the operation of spark plugs. To start the motor cold, gasoline was used, but as soon as the motor had started, a shift was made to tar oil. The author comes to the conclusion that tar oils are suitable for Diesel-type engines under certain conditions. (Maercks, Bochum School of Mines, in *Der Bergbau*, vol. 46, nos. 3, 4, and 5, Feb. 2 and 16, and Mar. 2, 1933, pp. 29–32, 45–46, and 61–63, 2 figs., *deA*)

INTERNAL-COMBUSTION ENGINEERING (See also Fuels and Firing: Bituminous Coal Tar as Fuel for Diesel Locomotives Underground)

Progress in Diesel Engines

THIS is a general survey, particularly of the work done in France, of which only a few parts can be here abstracted. Quite recently, Prettre found on the basis of new experiments that a distinction must be made between two different mechanisms of oxidation. It would appear well established that mixtures of air with vapors of combustible of the long carbon chain type are subject to oxidation reactions between 200 and 300 C (392 and 572 F). In these reactions, peroxides are supposed to play a considerable but not entirely well-known part and under certain conditions can produce explosive combustion. At about 300 C (572 F), however, these reactions are replaced by others. The velocity of these reactions increases slowly until ignition is produced.

According to Prettre, these reactions should not change in the flame, the products of slow combustion and of explosive combustion being analogous. The author refers to the work of other investigators, among them Grebel, who claims that very rich mixtures of hydrocarbons produced, by oxidation and cracking, oxygenated compounds, and aldehydes in particular. The following conclusions are drawn by the author from the work of Grebel and others:

Little is really known about this phenomena and experiments reproduce the actual conditions imperfectly.

According to the engineers of the French National Office of Liquid Fuels, before combustion and while at a comparatively low temperature, a mixture of liquid fuel and air must produce phenomena of oxidation with the formation of aldehydes, and particularly peroxides, which initiate ignition.

Above a certain temperature, which is a function of the nature of the fuel, these reactions are replaced by new reactions

common to the majority of fuels of the same nature, the velocity of the reaction increasing with the temperature and finally leading to ignition, providing the peroxides have not caused such ignition prematurely.

The author next considers the probable mechanism of ignition and combustion in a Diesel engine. He points out that the atomization of the droplet is produced in such a manner that a blanket of droplets is set up in the proximity of the injection nozzle. The air friction acts more powerfully at the droplets near the periphery of this blanket so that these droplets can leave their rectilinear paths. It has been observed that as the pressure progressively increases, the fuel blanket seems to consist of two parts, the internal, relatively clear and well defined, and a peripheral layer relatively opaque and with scalloped edges. It would appear, therefore, that an excessively high injection pressure with a nozzle of the same size might produce a less effective penetration, due to the fact that atomization begins too soon and the part of the jet where it begins to become opaque approaches the injection orifice when the pressure of atomization increases. All of this reduces in part the increase of the initial velocity of the first droplets formed and reduces the flow of the last droplets located in front of the fuel blanket.

The author also considers the timing of the various phenomena and the state of the fuel blanket during the very short instant between the beginning of injection and the time just previous to the ignition. This part, while of considerable interest, cannot be abstracted because of lack of space. (M. Gautier in *La Revue des Combustibles Liquides*, vol. 11, no. 102, February, 1933, pp. 54-58, last article of a series, *gt*)

Relation of Lubricant and Fuel to Carbon Formation With Special Reference to Gum

IT IS claimed that the basic cause of deposits of gum or carbonaceous material in an internal-combustion engine is incomplete combustion. Partial combustion of the lubricant is a necessary evil and non-volatile residues are left in the cylinder as a consequence.

The author reports a case in which a retailer of gasoline was sued for damages on the ground that the plaintiff was sold gasoline which contained 580 mg of gum per 100 cc of gasoline. It was claimed that as a result of using this gasoline in the tractors, power shovels, and trucks of a construction project, the engines of these machines were greatly damaged.

The writer states that it appeared from evidence brought out in the trial that the presence of 58 times a safe limit of gum in the gasoline may have had something to do with the damage caused. With the modern knowledge of control of gum in gasoline, such a case as the one described can justly be considered a rarity, but it showed that the infrequent instances of improper treating or handling of unstable gasolines may result in serious consequences.

In discussing the thermal stability of oils, the author states that high-viscosity oils are more subject to thermal decomposition in an engine than are those of lower viscosity. Blends of viscous and non-viscous oils change more than straight cuts of the same viscosity range in proportion to the percentage of highly viscous material used in blending. Lubricants prepared from residual stocks change more than either of the aforementioned types.

Under carefully controlled conditions in the same engine and using oils of the same base, the results of the Conradson test are roughly proportional to carbon deposits in the engine.

The author discusses next the appearance of resinic and asphaltic materials in the oil which, when treated, may crack down to leave a carbon residue. He ascribes this to partial oxidation which may be followed by polymerization. He says that methods now used for testing the stability of oils toward oxidation are probably somewhat unsuited for predicting performance in an engine.

The primary purpose of chemical treatment is to remove chemically unstable material from the oil and thereby decrease the possibility of change during service.

As regards carbon formation by motor fuel, attention is called to the presence of high-boiling-point, non-volatile material in the gasoline. Incomplete vaporization of the fuel may also cause incomplete combustion, as a result of its unequal distribution by the manifold to the cylinders. A discussion of the effect of gum-forming materials in gasoline is presented in detail. (Paul W. Stroud, Department of Petroleum Engineering, Colorado School of Mines. *The Oil and Gas Journal*, vol. 31, no. 46, Apr. 6, 1933, pp. 12 and 41, with brief bibliography, *p*)

LUBRICATION (See also Internal-Combustion Engineering: Relation of Lubricant and Fuel to Carbon Formation With Special Reference to Gum)

Propane in Dewaxing of Lubricating Oils

IN THIS process, said to have been developed by the Standard Oil Co. of Indiana, 25 to 30 per cent of oil is added to 70 to 75 per cent of propane, the mixture being under a pressure of 180 to 200 lb per sq in., at which pressure the propane remains liquid at temperatures of 90 to 100 F. This mixing is done in chillers of 1600 gal capacity each. There are two tiers of chillers, which are heavily insulated. When the mixing of the propane and oil is completed, the pressure in the chillers is gradually released. The attending drop in temperature may carry the solution as low as 40 F below zero. It is claimed that this "self-refrigeration" is cheaper and more efficient than the ordinary indirect refrigeration methods, the liquid being fluid even at this low temperature because of the large proportion of propane present in the solution. The propane is said to be completely recovered.

The vertical filter used on the new chlorex unit is described in the original article. According to the company technologist, the lubricating oil produced by this method has an excellent viscosity-temperature coefficient. (*The Oil and Gas Journal*, vol. 31, no. 50, May 4, 1933, pp. 11 and 45, *d*)

MACHINE PARTS

Cold-Driven Rivets

COLD-DRIVEN rivets in place of heated rivets were used on a 10,000,000-cu ft water-type gas-holder recently built for the Philadelphia Gas Works. In connection with this work, parallel tests with cold and hot rivets were made which revealed that with the former better filled holes resulted, higher yield points were the rule, and shearing strength exceeded 75 per cent of the ultimate strength. The heaviest work that was done on the gas holder required $1^{5}/_{8}$-in. rivets in $2^{3}/_{32}$-in. plates; the total thickness at the joint, including thickness of plate, butt strap, and curved angle, amounted to $5^{13}/_{32}$ in.

The rivets were made of standard boiler rivet steel, specified to be hot-made and self-annealed and to be "square-pointed." The heads of the rivets were button-shaped, with a diameter 1.5 times and a height 0.538 times the diameter of the rivet. The heads purposely were made no larger than actually neces-

sary to develop the tensile strength of the shank of the rivet, and a relatively small height of the rivet head permitted the head end of the shank to be more readily expanded, thus filling the hole completely instead of deforming the plate around the hole. The field-formed heads were driven flat to the same diameter as the manufactured heads and to a height of one-third the diameter of the shank.

Actual test values are reported in the original article. The shearing tests provided justification for the use of small manufactured rivet heads, since the unbroken rivets underwent a considerable stretch without pulling off the head.

The tests of the material in the driven and undriven split rivets showed conclusively the changes in the characteristics produced by the driving, the most noticeable of which was the high elastic limit produced by cold driving. (F. G. Thorn, Jr., Philadelphia Gas Works Co., Philadelphia, Pa., in *Engineering News-Record*, vol. 110, no. 24, June 15, 1933, pp. 784–785, 1 fig., *de*)

MACHINE-SHOP PRACTICE

The Hobbing Process

THIS is a general article on the subject, of interest because it describes some recent developments in hobbing practice.

Up to the present time, practically all spline shafts have been made with keys having straight and parallel sides. Now, however, many designers are considering seriously the adoption of a key design with the sides in the form of an involute curve. This change would simplify the task of producing the hobs as compared with the production of hobs with straight sides.

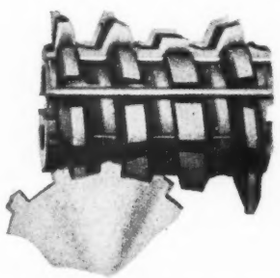


FIG. 2 ELONGATED-TOOTH HOB AND CROSS-SECTION OF WORK

A comparatively new type of hob is what is known as the single-position hob. This form is used to produce such shapes as ratchets, which, correctly speaking, cannot be hobbed. This hob is in reality a series of formed cutters on a lead, with each succeeding tooth cutting slightly deeper than its predecessor and a single tooth only doing the final finishing. This tooth must be set very accurately with respect to the center line of the work.

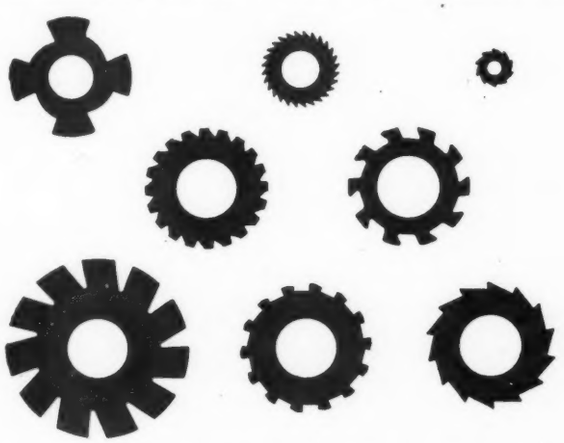
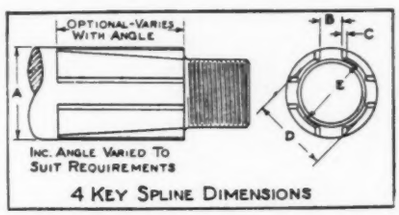
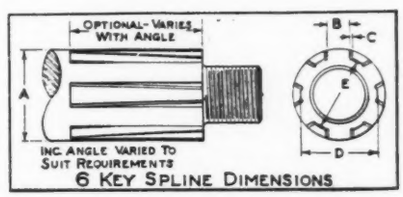


FIG. 3 SOME OF THE FORMS THAT ARE HOBBED WITH THE ELONGATED-TOOTH HOB SHOWN IN FIG. 2

A still later development is the elongated tooth hob, Fig. 2. The tool comprises a peculiar combination of a series of hobs and formed milling cutters, although it is operated as a conventional hob. It must be set very accurately with respect to the work. Fig. 3 shows a number of forms which can be hobbed with this tool and which could not be produced with the conventional type of hob.

A recent development in hobbing-machine construction is the tapered hob spindle. For a number of years it has been the practise to make the hole in a ground hob round and straight to a limit of plus 0.00025, minus 0.000. The hob is supposed to be a good slip fit on the hob spindle, but sooner or later the spindle wears, and even when new the hob may not run as true as it should. To get the best results from a hob, it ought to run true—at both ends—to within 0.0002 in. It has been found that by using a spindle with a steep taper, it is very much easier to obtain and hold an ideal running condition. This design has the added advantage of having the hob mounted on the machine under such conditions as obtained when the form was ground, and also when it was inspected.





FIGS. 4 AND 5 HOBS ARE NOW BEING MADE WITH WHICH THE KEYS CAN BE HOBBED ON A SPLINE SHAFT SO THAT THE KEYS WILL BE STRAIGHT AND PARALLEL BUT WITH THE ROOT DIAMETER TAPERED, AS SHOWN IN THE DRAWINGS

The latest development in the hobbing field is a machine which will automatically hob a spline shaft with the keys straight and parallel, but with the root diameter tapered. See Figs. 4 and 5. This machine is entirely special, not simply a standard machine to which a special attachment has been applied, but it is universal in that it will also hob any form which can be handled on the corresponding standard size. In addition to hobbing a tapered spline, it will also cut a helical gear which may have a shaft of the same diameter each side of the gear. An example of this is the gear in the center of a camshaft for driving the distributor. Another interesting feature of this machine is its ability to hob a worm gear by means of a tangential feed.

The hob required for the tapered spline is very special. Besides being tapered, the design includes a constantly varying pitch. The amount of taper in the shaft can be varied by gearing in the machine, within reasonable limits. (M. N. Hough, Barber-Colman Co., Rockford, Ill., in *Modern Machine Shop*, vol. 6, no. 1, June, 1933, pp. 7–15, 14 figs., *d*)

MUNITIONS

The Gerlich Rifle and Bullet

MODERN war conditions require a bullet of enormously high velocity, and the present velocity of about 2700 fps for machine guns and shoulder weapons using approximately caliber 0.30 is no longer sufficient. From the standpoint of interior ballistics, it is desirable to have a bullet which has little mass but great cross-sectional area, and hence low sectional density in order to give the powder gases a sufficient area upon which to push. An ideal bullet from this point of view would be one made of a cork-like substance. However, as soon as the cork left the muzzle of the barrel, it would be useless for flight through the air, because, from the point of view of exterior ballistics, it is desirable for a bullet to be of small cross-sectional area with the greatest sectional density. Such a bullet conceivably might be a darning needle made of some heavy material, such as tungsten.

The Gerlich rifle and bullet appear to have satisfied these conflicting requirements. The rifle has a tapered barrel with the contracting end toward the muzzle. The Gerlich bullet shown in Fig. 6 is fitted with two flanges which might be

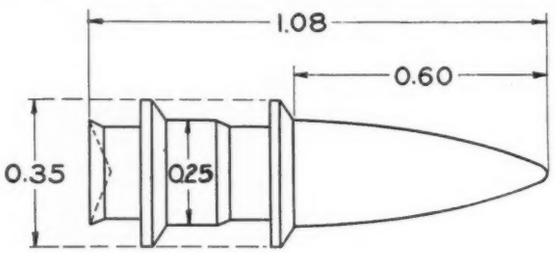


FIG. 6 BANDED TWO-DIAMETER GERLICH BULLET; CALIBER, 0.25; WEIGHT, 100 GRAINS

described as wings. These wings fit a grooved diameter and make a very good gas seal. As the bullet proceeds along the barrel it reaches the tapered portion where the wings begin to fold into the recesses cut in the cylindrical body, so that when the bullet leaves the barrel it is a smooth cylinder with good ballistic qualities.

Since only the narrow flanges touch the walls of the barrel, forcing resistance in the Gerlich bullet is at a minimum, although the gas seal is at the maximum. The amount of friction is reduced, and by the use of the right kind of powder, this type of bullet gives very high velocities. Gerlich's bullet, as usually proposed, is boat-tailed, but there is no advantage in boat-tailing a bullet at very high velocities, since at velocities much beyond that of sound, it is only the point of the bullet that encounters the air, leaving the remainder of the bullet in a vacuum.

If Mr. Gerlich had proposed to the author several years ago that a banded bullet would work in a barrel, the taper of which started at a point well forward of the chamber, and that the bands would fold into a recess as the bullet passed through the barrel so as to provide accurate flight through the air, the obvious answer would have been that there were several reasons why such a scheme would not work. These reasons are:

(1) The bands would not be able to stand the gas pressure.

(2) If the bands were strong enough to stand the gas pressure, they would be too strong to fold down.

(3) The bands would strip and fail to rotate the bullet.

(4) The interior of the bore of the barrel would be bulged when the bullet struck the resistance of the taper.

(5) The bullet would not fly true as the bands would not fold uniformly and the bullet would not be concentric.

However, since it has been demonstrated as a fact, it can be compared to Columbus' feat of standing an egg on end, which is easily understood after seeing it done. The barrel does not bulge because the bullet slides so easily on the bands that there is no tendency to check when it strikes the taper; the bullet does rotate properly because it starts turning immediately with the driving edge of the lands applied on the outer rim of the bands which are of considerably greater diameter than the bullet proper, thus supplying additional leverage.

Such bullets and barrels are difficult to make, and because of this, in the past, similar devices remained undeveloped. Now conditions are different. Anti-aircraft fire and anti-tank fire require high striking velocities; anti-aircraft, in order to reduce the time of flight; the anti-tank, in order to penetrate the armor. The Gerlich method promises increases in velocities of possibly 100 per cent rather than an increase in velocity of a mere 10 or 20 per cent. However, it is not all easy sailing. The cartridges for bullets made according to these principles, that is, the cork idea, are considerably larger and more bulky than the average infantry cartridge, although they shoot a smaller bullet. Such cartridges and such barrels are, in the present state of the art of manufacture, expensive, and do not lend themselves readily to quantity production. The development is still in the experimental stage. Because of the decreased size and the lack of space in the bullets or projectiles designed on the principle of the cork, it is more difficult to utilize such bullets and projectiles as tracers in the case of small arms and for explosive charges in the larger calibers. Changes are being made in armor-plate design at the present time, and some of these changes are such as to appear to be promising in so far as being effective against penetration of very small caliber bullets at very high velocities.

In summing up, it is considered that the development of weapons of extremely high velocity should be pushed, and it is believed that such a development is promising. There are many obstacles to be overcome, and it is too much to expect at the present time that anything very revolutionary will be accomplished in the near future. A valuable moral is contained in the prophecy by Colonel Heydenreich, who expected that shortly after the year 1908 ultra-high-velocity weapons would have replaced the conventional type. We are now in the year 1933, a quarter of a century later, and conventional weapons are still being used and will probably continue to be used for some time because of their simplicity and reliability. (Glenn P. Wilhelm, Major, Ordnance Department, Technical Staff, Office of the Chief of Ordnance, U. S. Army, in *Army Ordnance*, vol. 13, no. 77, March-April, 1933, pp. 264–267, 3 figs., *d*)

POWER-PLANT ENGINEERING

Mechanical Breakdowns of Prime Movers and Boiler Plants

THE author discusses primarily the metallurgical causes of breakdown of machine parts, such as weakness caused by segregation or blowholes. He also refers to faults of manufacture, such as bulging of cotter holes owing to, as he expresses it, the mechanic's excessive zeal with the sledge hammer when tightening up a key or to the hammering that has resulted in service from an ill-fitting key.

He discusses next the formation of cracks or faults and the use of the Izod, bend, and Brinell tests. He then proceeds to the consideration of failures in cranksafts and plain shafts, connecting rods, and crosshead bolts, plates in boilers, end

rings of turbine-driven generators, as well as the chemical embrittlement of boiler plates.

The article is of a strictly practical character, quite extensive, and not suitable to abstracting. The following is presented in an editorial on this paper in *The Engineer*, on p. 453: "It is a tiresome fact that unless some machine part is made of grossly unsuitable or defective material, is of hopelessly bad design, or is used with great ignorance of its capacity and capabilities, it may last for years in service before failure occurs. The reason is, no doubt, to be found in the generous factors of safety usually adopted by engineers, or in conditions of design which enforce the employment of dimensions greater than the stresses applied make necessary. But when we are faced with machinery details which have stood ten, fifteen, twenty, even forty years before failure, and have then been shown to be faulty in the metallurgical nature of the material, or in some other way unfitted to meet the stresses to which they are known to have been subjected, it is difficult not to feel, on the one hand, that blame for the failure cannot fairly be allocated to the maker, or, on the opposite hand, that the part was too generously proportioned for the duties it had to perform. Theoretically, it should be possible, in the light of modern science, to say with a very near approach to accuracy how long any given material of given dimensions and employed under given considerations will last before failure. That is not only theoretically possible, but has been approached in practice." (Paper before the Institution of Mechanical Engineers, April 28, 1933, by L. W. Schuster, abstracted through *The Engineer*, vol. 155, no. 4034, May 5, 1933, pp. 459–462, 8 figs., and discussion on p. 449)

Flame Radiation in Water-Cooled Boiler Furnaces

THE Royal Swedish Institute for Engineering Research carried out an investigation of pulverized-fuel practice in water-cooled furnaces. The experimental apparatus adopted consisted of a vertical furnace with double walls between which water circulated. The furnace, which consisted of six compartments, had an internal diameter of 800 mm (31.4 in.), a total water-cooled height of 4660 mm (15.27 ft), and a total water-cooled heating surface of 11.65 sq m (125.38 sq ft).

The powder with the conveying air flows tangentially into a cylindrical chamber, connected at the bottom with a slightly conical portion provided with welded-on spiral guiding rails at an angle of 45 deg and with its spiral slope contrary to the tangential inflow direction. The powder is centrifugalized against the walls owing to its strong rotation and is made to reverse its direction of rotation and follow the guiding rails on their downward twist. Because of its lightness, the conveying air is pressed in toward the center and therefore retains for the most part its original rotation direction. The powder and the conveying air thus rotate in opposite directions. The greater part of the air is carried in a tangential direction to a chamber surrounding the cylindrical chamber previously mentioned, and flows out in a direction opposite to that of the powder, which is thus surrounded by two currents of air rotating against it. That a powerful turbulence is thereby obtained could be seen during the tests through the inspection window above the burner cupola. The stream of powder was subjected to dispersion by the two currents of air and gradually forced to change its direction while simultaneously thorough mixing was effected.

The coal burner was supplemented by a centrally fitted oil burner, which was used for starting and also in connection with pulverized coal of the anthracite type.

The ash, which did not escape with the gases through the air preheater to the chimney, collected in the bottom of the furnace and in the angle in front of the air preheater.

The remainder of the article is devoted to the details of the experimental installation and a discussion of the fuel.

From the summary it would appear that if a comparison is made between the results of the heat irradiated by, for example, oil flames and pulverized-coal flames, it is found that an oil flame radiates a greater percentage of the heat value in the fuel than a pulverized-coal flame, but the difference is not very considerable. The radiation in the first part of the flame seems to be more intense in the case of oil fuel than in that of coal fuel, which is due to the fact that the average size of the radiating particles is considerably less in oil flame than in pulverized coal flame. Thus, while up to 30 per cent of the heat value of the fuel could be utilized on the first 660 mm (25.98 in.) of the path of the flame with oil fuel, the highest corresponding value with pulverized coal is 24 per cent.

This paper and a preceding one (paper no. 66 of the Proceedings of the Royal Swedish Institute for Scientific-Industrial Research) afford certain possibilities of calculating at least approximately the flame radiation in different kinds of combustion chambers. With the development of the steam boiler in the direction of radiation boilers, that is, with the combustion chambers entirely enclosed in heating surfaces, these calculations become of greater importance than hitherto. (*The Fuel Economist*, vol. 8, nos. 91 and 92, April and May, 1933, pp. 439–442 and 491–494, 4 figs., *e*)

Slime and Mussel Control in Surface Condensers and Circulating-Water Tunnels

WHERE circulating water is obtained from fresh water supplies, the problem generally will be limited to slime deposits only, but the use of salt or brackish water introduces additional difficulties from seaweed and crustacean growths. The author gives some information as to the character of slime deposits and devotes his article chiefly to the subject of "de-sliming" by chlorine. No specific dosage of chlorine applicable for all conditions can be established. Usually, however, the amount of chlorine necessary to effect proper de-sliming, when using the intermittent method of application, will be between 0.4 and 5.0 ppm. In rare cases, the dosage may be as high as 8 to 10 ppm. The best results on condenser tubes are obtained when the condensers are thoroughly cleaned mechanically prior to initial chlorination. The author discusses next continuous versus intermittent chlorination and recommends obtaining definite information concerning the chemical constituents and bacterial flora of the water which is to be chlorinated.

As regards the cost of treatment, it is said that this will depend entirely upon local conditions, and the effects will depend upon the character of the slime formed on the tubes and periods between cleanings. In a recent study of fourteen installations of this type, the average saving in tube cleaning was 28 man-hours per week per condenser, but the greatest saving from the treatment is due to the increased vacuum resulting from more efficient condenser performance.

Methods of testing for residual chlorine are given in the original article. The next treatment discussed is the copper-sulphate treatment. The dose of copper sulphate ranges from one part per 100,000 parts of water to one part per 10,000,000 parts of water. It is said not to be as practical a method as chlorine and is objectionable in that, being an acid salt, it increases the corrosive properties of water when used in very heavy doses. It is not very effective against full-grown mussels. One of the most effective methods for killing mussels

is to raise the temperature of the water, since this species of crustacea cannot survive in water at temperatures of 106 F or higher. The mechanics of this method of operation are discussed in detail in the original article.

Electrolytic prevention of slime and other deposits has been practised for a number of years but has been limited to a relatively few plants. The process is based upon the theory that corrosion of condenser tubes and slime deposits upon metal surfaces are retarded when the tubes are maintained in a cathodic state. This condition is effected by an electromotive force applied externally through the condenser or other equipment requiring protection. The largest installation in this country is at the Long Beach Station, Plant No. 2, of the Southern California Edison Company. A direct current is supplied to the anodes at from 6 to 10 volts from a motor-generator set. The current density is from 2.5 to 5.0 amperes per 1000 sq ft of cooling surface. It is reported that the apparatus has greatly inhibited rapid tube corrosion and has assisted in keeping down slime deposits, but de-sliming with chlorine is also used at this station. At three stations in the East, supplementary chlorine treatment is not used. It is possible that the slime control is effected by the chlorine generated by electrolysis of the salt water. (First of a series of articles by Sheppard T. Powell, Consulting Chemical Engr., Baltimore, Md., in *Combustion*, vol. 4, no. 10, April, 1933, pp. 7–13, 7 figs., *d*)

New Benson Boiler Developments

THE article here abstracted is based on preliminary notes received by the editor of *The Steam Engineer* from the Siemens-Schuckertwerke of Berlin.

The tube failures that occurred in the first Benson boiler installations were definitely found to be due to salts contained in the feedwater. Extensive tests carried out with various salts and different concentrations showed that the deposits always take place at certain parts of the heating surface, which is, roughly speaking, the zone of conversion of water into steam. If such zone of deposits is exposed to high rates of heat input by radiation, it is obvious that the tubes become too hot and eventually burst. This trouble, however, is easily overcome as soon as the zone of deposits, which in fact is but very small, is placed in a range of lower flue-gas temperatures.

The above theory has been proved in many practical cases in so far as Benson boilers, in which the conversion zone was originally exposed to radiant heat, were rebuilt later in such a way as to move the said zone to lower flue-gas temperatures, with the effect that all tube failures which had originally occurred ceased entirely. This was the case with the Benson boiler on the steamer *Uckermark* as well as with the cableworks installation at Berlin-Gartenfeld and the Langerbrugge boiler in Belgium, all of which gave most satisfactory results after they were rebuilt in this manner.

It was doubtless a disadvantage of the Benson boiler that even in cases when steam was required at relatively lower pressures it had to be generated at the critical pressure of 3200 lb and afterward be throttled down. On the other hand, all trials to generate steam in a forced-flow tubular boiler below the critical pressure (and there were many such trials ever since the days of Perkins and DeLaval in the last century) had failed, or at least those boilers were not able to work in continuous operation.

The causes of these failures were for a long time believed to lie in the mixture of water and steam, and for that reason Benson's invention to generate steam without ebullition at the critical point was so readily accepted by engineers. Recently, however, after the salt problem was found to be the main problem of critical steam generation, it could be concluded that a similar problem would also prevail below the critical pressure, and it seemed probable that not knowing about this problem had been the true reason why the earlier work of other inventors in the field of under-critical pressures had failed.

As a matter of fact, Siemens-Schuckertwerke have found similar laws for the deposit of salts in tubular boilers below the critical pressure as they had first found for the critical pressure itself. They also report that similar remedies were found, viz., the placing of the zone of deposits in a range of lower flue-gas temperatures, and also methods of efficient blow-down, so that Benson boilers can now be operated safely also much below the critical pressure. The chief advantage of this undercritical operation is that no excess feed-pump work is required.

The first trials to operate a Benson boiler at undercritical pressures were made by Prof. E. Josse, of the Technische Hochschule, Berlin, with the test boiler of his laboratory. Later, Siemens-Schuckertwerke operated their large (40 tons per hr) Benson boiler No. II at the cableworks at Berlin-Gartenfeld below the critical pressure, and recently the Benson boiler on the *Uckermark* (20 tons per hr) has been worked at 1000 lb, which is little above the turbine pressure to which formerly the steam had to be throttled down. The Langerbrugge Benson boilers (135 tons per hr) are still operating with the critical pressure, because in this plant the high pressure is fully utilized in a turbine.

In the future, the Benson boiler with critical pressure will be used in all cases where large units and high load factors call for a maximum efficiency. In all other cases, however, where lower turbine pressures are chosen, the Benson boilers will be operated at accordingly lower pressures. This undercritical Benson boiler, which embodies all experiences gained with the critical Benson boiler, is claimed not only to replace all other tubular boilers tried so far without success, but also to be widely used where drum boilers are now installed, because it represents the simplest and most suitable boiler construction for modern purposes.

Based on the fact that the Benson boiler can also be operated safely below the critical pressure, Siemens-Schuckertwerke have developed a new method of boiler and turbine operation, the main feature of which is the omission of the control of the turbine-entrance pressure.

It is obvious that a turbine can be operated with varying live-steam pressures, but with respect to boiler operation, it has been the custom in power generation to maintain a constant pressure before the throttle. With the new type of Benson boiler, the pressure must not be maintained constant, but it is easily possible to deliver steam of any pressure at practically constant temperatures.

Siemens-Schuckertwerke have therefore suggested the operation of the turbine with the maximum pressure at maximum load, letting the pressure adjust itself automatically at partial loads. This is done by the omission of the throttle valve at the turbine inlet and by adjusting the boiler output directly in proportion to the turbine load. The turbine construction thus becomes much simpler and the feed pump does not have to work against higher pressures than those just necessary.

A detailed project has been worked out by Siemens-Schuckertwerke for a peak-load central station with 500 lb normal and 2000 lb peak pressure, giving a turbine output from 5000 kw to 20,000 kw. The operating advantages of such a plant working with variable pressures are claimed to be enormous, and the first costs referred to maximum capacity are surprisingly low. Also, in industrial plants, the application of variable pressures offers considerable advantages in many cases. (*The Steam Engineer*, vol. 2, no. 9, June, 1933, pp. 387–388, *d*)

PUMPS

Adjustable-Blade Propeller-Type Pumps

ADJUSTING the runner blades of propeller-type pumps improves their characteristics just as it does those of the propeller-type turbines. The discharge of a pump can be held constant while the head is varied over a wide range, or the head may be held constant and the discharge varied, either with good efficiency. Performance curves of an 11-in., model, adjustable-blade pump in an involute setting as obtained by the I. P. Morris Division, Baldwin-Southwark Corporation, are given in the original article for four blade positions, with the runner operating at 1000 rpm. Other curves show the relation between quantity and efficiency for the head indicated.

The performance of the adjustable-blade pump, operated to give a constant discharge of 5.25 cfs under heads of 5.7 to 9.6 ft, is compared with that of a fixed-blade pump. At maximum head, the efficiencies of both pumps are the same, about 73 per cent.

From the curves given it would appear that over practically the entire range of head, except at maximum head, the efficiency of the adjustable-blade pump is materially higher than that of the fixed-blade pump. A disadvantage of the propeller-type high-speed pump is the power consumption required to operate it at full speed against a closed discharge valve. But this disadvantage can be eliminated by adjusting the blades during operation, and it has been shown that it is possible to operate adjustable-blade pumps at full speed against the closed discharge valve without overloading the motor.

The original article contains data on the blade-adjustment mechanism, and the uses of adjustable-blade propeller pumps. (R. E. B. Sharp, Hydraulic Engineer, I. P. Morris Div., Baldwin-Southwark Corp., in *Power*, vol. 77, no. 5, May, 1933, pp. 242–243, 6 figs., *e*)

SPECIAL MACHINERY

Hay Driers

THIS article contains a description of two types of machines said to be new, one being of the low-temperature conveyer type (developed by J. H. Fulmer, of Nazareth, Pa.) and the other of the high-temperature rotary-drum type, owned by the Pennsylvania State College.

In the Fulmer type, the gases from the furnace are diluted with air to a temperature of about 290 to 330 F. The fan forces them through a tunnel underneath to the end of the drier where dried hay is discharged. The gases then pass through the mat of hay five times in the small machine (two sizes have been built), the last time being through the green hay. In a way, the counterflow principle is used, in that gases and hay travel in opposite directions. During the test made by the author of the original paper on the small machine, the conveyer traveled 2.87 fpm, which kept hay in the drier about 36 min.

Two features of the conveyer drier are of particular interest and are claimed to be new. The first of these is the mat-forming device. One of the drawbacks in the past has been that the mat of hay was not be uniform and was likely to have loose spots. Most of the drying air would pass through these loose spots, over-drying them and leaving dense spots still wet. The Fulmer mat former is said to give a uniform mat automatically. The second feature is the good thermal efficiency. Tests showed a thermal efficiency of at least 63 per cent using hard coal as fuel. Details of tests are reported in the original article. Radiation and leakage from tunnel and drier and unaccounted losses amount to 16 per cent.

The second part of the article reports tests on the rotary-drum high-temperature drier. In this case, the thermal efficiency is around 58 per cent, and it has been fairly well established that the fuel cost for hay with 60 per cent of moisture is about one-half of that with 70 per cent of moisture, so that a saving in fuel may be expected by using natural drying to help artificial drying.

The Dairy Department at Pennsylvania State College believes that the feeding value is not hurt by a moderate amount of field drying. At least there appears to be no loss of leaves until the moisture is below 50 per cent.

The article gives $4.20 as the operating cost per ton of dried hay, which covers, however, only fuel oil, labor, power, and estimated repairs, and does not include overhead. The statement is made that if only 150 tons were dried each year, the overhead might be as much as the operating cost.

It is expected that the cost of drying may be reduced by cutting down the losses of heat, but such progress must be rather slow because no single loss is very great, and the main opportunities for savings would seem to be lower overhead cost by drying more tons per year, using long-lived machines or apparatus of lower first cost, and lower labor requirements by more automatic operation, the present methods of handling the dry hay being often rather crude. (Paper by A. W. Clyde, presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, November, 1932, abstracted from *Agricultural Engineering*, vol. 14, no. 5, May, 1933, pp. 127–129, 1 fig., *pe*)

SPECIAL PROCESSES

Synthetic Rubber in Russia

IT IS stated that two plants for the manufacture of synthetic rubber are in operation, a third one is under construction, and two more are planned. In two of these plants, alcohol derived from potatoes is used as the basic material, which is unfortunate as the demand for potatoes as food equals or even exceeds their supply. Two solutions of this difficulty have been proposed. First, a process of obtaining alcohol from peat has been worked out, and next, the State Institute of Applied Chemistry has announced a new method of obtaining synthetic rubber from acetylene. Tests of the new rubber are said to have established in some respects its superiority to natural rubber, while the cost of production, according to preliminary estimates, is considerably below that of synthetic rubber manufactured by other known methods.

Intensive work is being done in the way of extending the cultivation of native rubber-bearing plants. Among these is the plant called tau-sagiz, already grown in Asia and capable of being cultivated in European Russia. Several other plants have been discovered containing high percentages of rubber, such as the hondrilla plant and the Crimean dandelion. In both the tau-sagiz and the Crimean dandelion, which apparently belong to the same family, the rubber is found in the form of threads in the roots. (*Soviet Union Review*, vol. 11, no. 4, April, 1933, pp. 92–93, 1 fig., *d*)

THERMODYNAMICS (See also Power-Plant Engineering: Flame Radiation in Water-Cooled Boiler Furnaces)

Study of the Transmission of Heat

IN CONNECTION with the investigation of the effect of roughness of surface of heat-transmitting tubes on heat transmission, the author claims to have found that when heat is

transmitted between some fluid of a fixed nature and the heat-transmitting surface only by the action of convection and conduction, the heat-transmission phenomenon is controlled by the boundary layer of the fluid in contact with the heat-transmitting surface, and the boundary layer, in turn, is controlled by the velocity of flow of the fluid, the diameter of the heat-transmitting tubes, and their arrangement.

These factors all tend, in the opinion of the author, to destroy the boundary layer of the fluid from the outside. The author claims, however, that this boundary layer can be more efficiently destroyed from the inside, as, for example, by providing extremely keen-edged projections on the heat-transmitting surface. (Original article in Japanese by Kôtarô Uhira, in the *Journal*, Society of Mechanical Engineers, Japan, vol. 36, no. 191, March, 1933, pp. 165–171, 24 figs., *e*)

The Process of Steam Generation

AS EARLY as 1822, Faraday observed a finite temperature difference between the liquid and the vapor during the process of steam generation. Since this observation did not agree with the French theories which dominated the field at that time, it was Gay-Lussac's claim that the vapor and the liquid were at the same temperature that has been universally accepted, even though no tests to establish such a theory were made.

In 1921, the present author returned to Faraday's observation, but his work has not been generally accepted. Only since 1929 has enough experimental evidence accumulated to show that there may be temperature differences between pure water and the vapor generated therefrom.

The author starts by quoting the work of Jakob who quotes the well-known Thomson equation by virtue of which vapor pressure over curved surfaces depends on the curvature of the latter. The present author questions the general application of this equation, but says that it is advisable to avoid the formation of bubbles in the investigation of the process of evaporation. Heidrich, in a thesis presented at Aachen in 1931, described evaporation experiments in which bubble formation was carefully eliminated. To accomplish this, the boiler was placed in another vessel in which a solution of calcium chloride was brought to such a temperature that the water in the inner vessel evaporated without the formation of bubbles.

In his thesis, Heidrich presented the results of his observation in the form of curves only, and the curves themselves were reduced to such an extent that they could not be used for numerical evaluation. The author secured from Heidrich blueprints of the original data from which measurements could be made with sufficient precision. Because of the general unavailability of Heidrich's work and because of this recalculation of Heidrich's data by the present author, this part of the article is of considerable interest but cannot be abstracted here because of lack of space.

Heidrich not only established that there is a temperature difference between the vapor and the liquid wherefrom it is originated, but also introduced a factor w expressing the velocity of variation of temperature produced by the motion of the water. This introduces the thought that the difference in the temperatures of the water and the vapor may depend on the velocity of evaporation itself. In particular, Heidrich found that where vapor is formed from pure water without the production of bubbles, there is a finite temperature difference between the steam and water equal to $0.036\ G$ in centigrade units, G being the velocity of evaporation in kilograms per square meter per hour. The fact that the value for heat conduction obtained from Heidrich's observations agrees so well with other observations, might, in the opinion of the author, be taken as confirmation of the correctness of other consequences derived from Heidrich's data.

Notwithstanding the fact that, according to the present author, it has been consistently denied, the presence of such a finite temperature difference has been observed for a long time. Thus, according to instructions for the calibration of the boiling point on thermometers, the latter should not be immersed in water, because the water has too high a temperature. This was explained on the assumption that the water was impure, and yet the temperature difference so observed was due exclusively to the velocity of evaporation.

The author next discusses temperature differences due to osmosis. As observed by Heidrich, the temperature difference in the case of evaporation should have a sign opposite to that in the case of the liquefaction of a vapor. The liquid which causes the liquefaction must be colder than the steam and be subject to exactly the same dependence upon the velocity of the process. If the temperature difference is plotted as a function of the velocity of evaporation or condensation, a straight line results.

The remainder of the article is devoted to a discussion of the difference of temperature between water and steam as determined by measurements at the Physico-Technical Reich Bureau as carried out by Jakob and Fritz, particularly their most recent work. The author points out particularly that in steam generation as it is carried on in power-plant boilers, many factors come into play. He claims that even in the tests carried out by Jakob and Fritz entirely too many variables were present to permit a strictly correct discussion of results, and that the tests made by Heidrich are superior in this respect. He points out particularly that in the Jakob and Fritz tests there was a material formation of bubbles, which involved a transformation of heat energy into surface and space energy, and that the latter is reconverted into heat when the bubble bursts. Moreover, the facility with which bubbles form depends also on the gas content of the water, the roughness of the heated surfaces, the motion of the water along these surfaces, and possibly other factors. In their turn, the bubbles produce a disturbance in the motion of the water, as they rise faster than the heated water. When bubbles are present, there is never such a quiet movement of the liquid as was obtained by Heidrich.

Furthermore, it is impossible to determine whether the entire formation of steam takes place through the intermediary bubbles or whether, as in Heidrich's tests, it is generated at the surface itself. In tests with plates, where formation of bubbles is interfered with, some of the steam is certainly generated at the surface. In any event (as was pointed out by Planck on Nov. 9, 1930), it is impossible to expect a thermal equilibrium at the surface of a liquid emitting vapor, as there is there no mechanical equilibrium; which means that when vapor is generated with finite velocity, there must be a finite temperature difference prevailing at the surface. This should be measurable, as it was by Heidrich. (K. Schreber, Aachen, in *Zeitschrift für Technische Physik*, vol. 14, no. 2, 1933, pp. 81–85, 1 fig., *et*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

The Flow of Fluids in Closed Conduits

(*Continued from page 501*)

CONCLUSIONS

(1) From the data, it is apparent that the friction factors for all types of rough surface approach the values for smooth conduit as the diameter increases.

(2) The resistance of very small brass tube, 6- to 12-in. steel pipe, 9- to 16-in. galvanized pipe, 20- to 48-in. best cast-iron pipe, smooth cement and light-pressure plate ducts, 48- to 96-in. average cast-iron pipes and average concrete pipes, and 72- to 120-in. brick tunnels is the same. A similar diameter relation holds throughout the ranges of size.

(3) The roughness effect for any type of conduit can be estimated from the average rugosity.

(4) The effect of age and consequent tuberculation in steel and uncoated cast-iron pipe is largely that of reduction in real diameter in large pipes, and of both reduction in diameter and increase of roughness in small pipe. The carrying capacity of small pipes will therefore decrease more rapidly with age and corrosive fluids than it will with large pipe. This phase of the problem is chiefly limited to water service.

(5) The value of the friction factor f must lie between the smooth-pipe curve and a constant value of approximately 0.054 for entirely rough surfaces.

(6) Friction drop in tube nests may be safely calculated on the basis of entirely rough conduits.

The data and conclusions here given are by no means final, but it is believed they present a logical explanation of the large variations occurring in tests of rough conduits. All of the data are for clean conduit; no attempt to allow for encrustation or other reduction in diameter has been made.

While the writer has not presented a solution reduced to convenient charts, it is hoped, however, that this study offers some broadly supported information that will help in generalizing two simple formulas to cover the whole range of flow of homogeneous fluids. The subject is so broad that no attempt has been made to give complete details; most of the supporting data will be found in the paper by Kemler.

The Break-Even Chart

(*Continued from page 496*)

in order to determine how and to what extent they may be made to vary with activity. Variable budgets should then be charted in order to determine the special economic characteristics of the items of fixed expense. When this has been done, the break-even chart may be modified to suit the particular business.

(4) The modified break-even chart constitutes a variable budget. As labor rates change and methods are improved, costs change, so that the chart should be revised at least twice a year at six-month intervals, and more frequently if necessary. During the period of time for which the chart is effective, the relationship between expense, income, and activity should be as shown on the modified break-even chart, provided the average of selling prices remains the same. When the average of selling prices is changed, it is a simple matter to superimpose a new income line on the break-even chart.

(5) If it is assumed that the capital employed in the business shown in the accompanying charts is turned over twice a year, the percentage of profit on the capital employed will be double the percentage of profit on sales shown in the normal sales dollar; in other words, instead of a 3.3 per cent profit, there is a 6.6 per cent profit on the capital employed. It is apparent that the economic characteristics of the business shown on the accompanying charts are unsatisfactory, and therein lies the value of the break-even chart, for it discloses an inadequate profit at normal activity and a break-even point at a relatively high activity, which would mean that losses would occur with a slight drop in volume of sales. When it is stated that a 6.6 per cent profit on the capital employed is an inadequate profit, it must be remembered that Federal taxes, interest on borrowed money, appropriations for betterments, provision of part of the surplus for pensions, etc., as well as preferred- and common-stock dividends, all have to come out of the profit referred to.

IMPORTANCE OF THE BREAK-EVEN CHART

In closing, it is desired to point out that the special economic characteristics referred to apply to a single industrial organization that is a part of an industry. From the point of view of the individual organization, we have learned in recent years that the fixed quarterly, semi-annual, or annual budget is not flexible enough to insure proper control of expense, or else that we are not endowed with sufficient prophetic vision to enable us to forecast the volume of business to be realized, on which to base the budget. Economic necessity has driven the individual organization to look for a more flexible medium of expense control. It is assumed that readers will appreciate that the major portion of the expenses subject to control consists of the wages of men. We are, therefore, forced to contribute to human misery by dropping men from the payroll when sales volume falls. Anything that may be done to eliminate fluctuations in activity is, therefore, of decided benefit to the industrial worker. Since the laws developed by Professor Rautenstrauch may be applied to industry in the aggregate as well as to the individual organization, we may reasonably hope that an appreciation of these laws on the part of those who control the many organizations in an industry and on the part of those who finance industry, may lead to more stable conditions of production.

BECAUSE engineers, in their normal business of production, construction, and technical service, will be actively concerned with human relations and social welfare, it does not follow that they will necessarily displace bankers, lawyers, economists, journalists, social workers, and politicians in the direction of our common concerns. The engineer has his gifts, but also his limitations. His field of natural leadership is that of factual, analytical, constructive planning and action on material problems. The management of money and men is not his domain by inherent right, but because it cannot be disentangled from his material responsibilities. In a certain sense, the engineer's habit of factual, analytical, and constructive thinking is incompatible with philosophical thinking involving conflicts of value and with judicial thinking involving conflicts of human interest. This incompatibility tempts the engineer to disparage generalized thinking and to express impatience with economists who cannot make up their minds. The engineer's scale of social values, I believe, is sound within its limits, but still inadequate for the broader phases of public leadership. While he will be increasingly affected by the so-called social sciences, there is little prospect of their soon attaining to that stage of predictive control which would put their practical execution into his hands. Economics, sociology, and government are, in fact, aspects of social psychology, and in their practical aspects, fully as large scope must be left to sheer insight and sagacity as to any scientific technique.—From an address by William E. Wickenden, President, S.P.E.E., at Madison, Wis., July 6, 1933.

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

World Petroleum Combine

TO THE EDITOR:

Senator W. G. McAdoo recently introduced a bill into the Congress for another investigation of the oil industry, making a charge that it seeks to form a world combine. As a matter of fact, the oil industry needs a world combine, just the same as the wheat growers of the world need the combine which the government is attempting to put through. Petroleum is not only a national resource that should be conserved, but is also a world commodity which is exhaustible, never to be replaced when once used.

It is impossible to conserve petroleum at present ruinously low prices. Therefore, the world price must be raised to a point where the producer and refiner can practise conservation. As an engineer, I can assure you that it is now practicable for the world to produce twice as much gasoline from a barrel of crude petroleum as it does at present. We are now wasting an enormous amount of oil in the form of worthless coke, fixed gases, and fuel oil which is being burned under boilers instead of coal. With a world combine and a fair price for petroleum and gasoline, we could run all automobiles on half the crude oil now being used. A fair price will permit the refiner to install more cracking plants and hydrogenation plants, and the producer can exist comfortably with half the present production. The public would pay only a few cents more for gasoline, and would be assured of a supply for twice the length of time.

G. C. DAVISON.[1]

Lyme, Conn.

The Economic Characteristics of the Manufacturing Industries

TO THE EDITOR:

The correspondence in reply to Dr. Rautenstrauch's paper[2] as published in the May, 1933, issue of MECHANICAL ENGINEERING has created considerable discussion, and indicates, in some instances, that the full possibilities of the original paper have not been realized. Perhaps a mention of one important point might be helpful.

Dr. Rautenstrauch's work is based on the fact that it is probable that future operation of an industry will fall within certain limits, provided the conditions of nurture remain constant in nature. From past experience, we establish the mean of operation in the given industry, as well as the deviation from this established condition. From this "hind-sight," the probability of future operating conditions is predicted, such prediction of future performance to fall within certain bands of operation, as will be illustrated and explained for the break-even chart.

Any analysis that unduly complicates the break-even chart will tend to defeat its purpose. Naturally, complicated mathematical analysis may fit the past data better than the method presented by Dr. Rautenstrauch; but will it give an equally probable prediction of future performance? Certainly the method of least squares can be applied to the analysis; but is that method the best one possible? Also, in the least-squares method of analysis, there are three different procedures possible: (1) the condition that makes the sum of the residuals least for X on Y; (2) the one that makes the normal from the (X, Y)'s the least; and (3) the one that makes the residuals least for Y on X. Fig. 1 shows these three cases. In all of them the residuals will be zero, and the sum of the squares of these deviations will tend toward a minimum for the derived regression line computed from any one of the three methods.

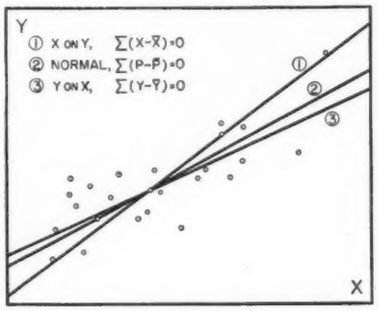


FIG. 1 DIFFERENT LEAST-SQUARES FITS

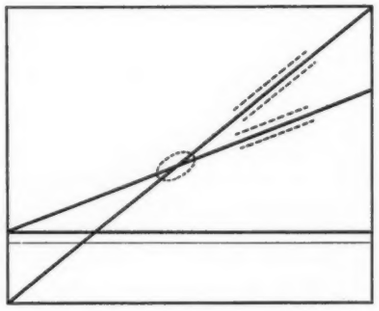


FIG. 2 BREAK-EVEN CHART WITH OPERATING BANDS

For each method of computation, a new zero-ordinate intercept will be obtained. This, however, is not in accord with the principle upon which the break-even chart was constructed. The income line must have its original at zero-zero, while the cost line can have only one intercept at the zero ordinate determined by the fixed charges of the specified industry, and no other value, such as would be given by any method of least squares. This shows that although the method of least squares may be correct in its technique, there is no justification for the belief that such method is the best.

The break-even point will shift with every change in the method of computation employed. The band in which it will most probably fall is more important than any scheme so foolish as to assert, "this is the point."

The data furnished in Dr. Rautenstrauch's Fig. 2 show that

[1] President, Bed Rock Petroleum Co., Huntington, West Virginia. Mem. A.S.M.E.

[2] See MECHANICAL ENGINEERING, vol. 54 (1932), pp. 759–770.

to obtain an equation of fair fit requires that it be of the seventh degree; and one for the best fit requires that it will be of the eleventh degree. Extrapolation with such equations would be foolish.

One method that can be used for detecting variations in costs and income with the passage of time is to take the means of four successive groups, or even the mean of one. Parallel lines are drawn at distances of one and one-half times the general standard deviation above and below the general mean. This distance corresponds to three times the standard deviation which the means of four would have if the observations were independent. Only those items need investigation that fall above or below the level of the parallel lines so drawn, as they are outside the probable limits expected by chance. Convenience of calculation plays a part in choosing four as the number in a group. Another method is to test for excessive values of "chi squared," in conjunction with suitable tables, as an indication of the advisability of looking for trouble.

The region within which the most probable value of the break-even point may be expected to be found can be shown statistically to be a flattened oval. This outline of the area is due to the non-normal distribution of the deviation.

It is my opinion that stress and reliance should be placed on the analytical mathematical methods, which can afterward be shown graphically for convenience of understanding. The methods suggested above are graphically illustrated by Fig. 2. The parallel dotted lines could have been shown converging at the ends; most probably they should be so shown, indicating regions of poor extrapolation.

Statistically, the methods presented by Dr. Rautenstrauch seem to be subject to the minimum error when the break-even chart is used for purpose of budget or production control. The addition of bands of operation further tends to define the economic characteristics of the industry being studied.

E. DILLON SMITH.[3]

New York, N. Y.

The Origin of the "Corliss" Valve

TO THE EDITOR:

In connection with the article on George H. Corliss in your July issue, I send you a copy of a letter dated March 14, 1931, from Dr. F. R. Low, a photograph of a sketch, and a quotation from *Power*, November, 1889. These relate to the origin of the "Corliss" valve. The sketch, creased and worn, with the date and time noted on the back, is framed and in the library of the New York Museum of Science and Industry. See Fig. 1.

Dr. Low's letter reads as follows:

In early days of my connection with *Power* I spent a forenoon with William Wright at his engine works at Newburgh, New York. He was foreman for George H. Corliss when the Corliss engine was being introduced. The flat slide valves with which the earlier engines were equipped did not respond readily to the release and closing mechanism.

Among the early customers was the Eddy Street Foundry, of which the father of William A. Harris, who later built the Harris-Corliss engine, was superintendent. The engine was for the most part completed, but the finishing of the cylinder had been delayed pending the development of a more satisfactory valve.

Mr. Wright in telling me this went to the safe, and took from between the leaves of an old notebook the sketch which I am sending herewith. Mr. Harris was getting impatient for delivery. One afternoon when the subject of the valves was under discussion, Mr. Wright produced this sketch, he said, and proposed to make the valves in this way. The suggestion did not meet with immediate favor and he put the sketch into his pocket. It is, as you see, a drawing of a cylinder fitted with the semi-rotary steam and exhaust valves which became characteristic of the Corliss engine.

When he showed this to me in 1889, the inscription "April 17, 1849, two o'clock p.m." was still decipherable in faded brownish ink. After Mr. Wright's death, the sketch was presented to me by his daughter.

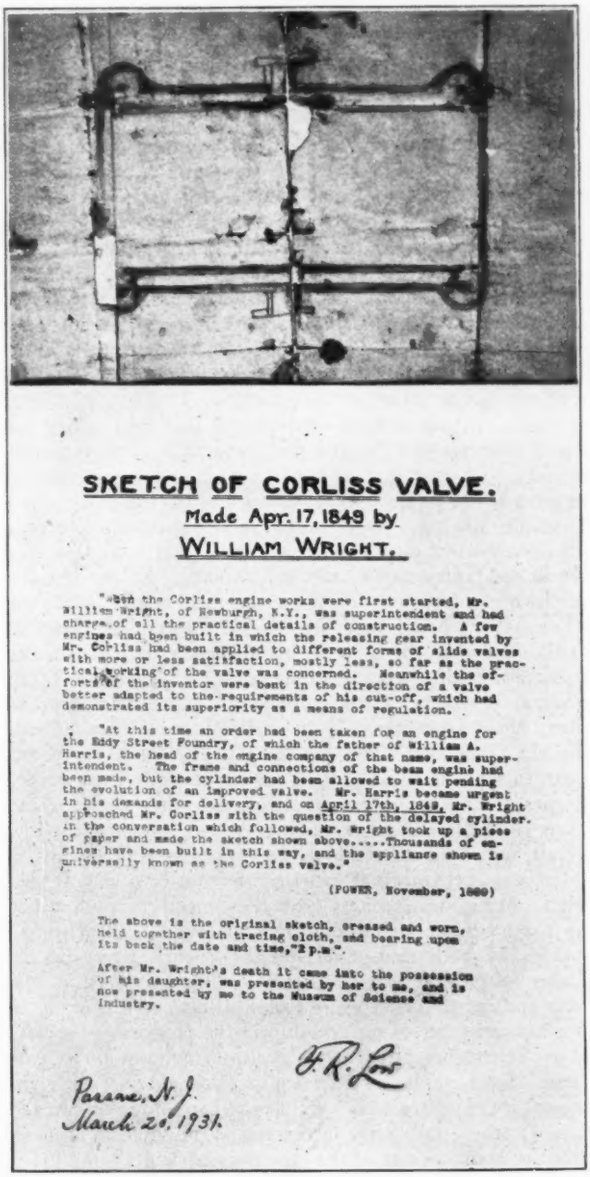

SKETCH OF CORLISS VALVE.
Made Apr. 17, 1849 by
WILLIAM WRIGHT.
"When the Corliss engine works were first started, Mr. William Wright, of Newburgh, N.Y., was superintendent and had charge of all the practical details of construction. A few engines had been built in which the releasing gear invented by Mr. Corliss had been applied to different forms of slide valves with more or less satisfaction, mostly less, so far as the practical working of the valve was concerned. Meanwhile the efforts of the inventor were bent in the direction of a valve better adapted to the requirements of his cut-off, which had demonstrated its superiority as a means of regulation.
"At this time an order had been taken for an engine for the Eddy Street Foundry, of which the father of William A. Harris, the head of the engine company of that name, was superintendent. The frame and connections of the beam engine had been made, but the cylinder had been allowed to wait pending the evolution of an improved valve. Mr. Harris became urgent in his demands for delivery, and on April 17th, 1849, Mr. Wright approached Mr. Corliss with the question of the delayed cylinder. In the conversation which followed, Mr. Wright took up a piece of paper and made the sketch shown above.....Thousands of engines have been built in this way, and the appliance shown is universally known as the Corliss valve."
(POWER, November, 1889)
The above is the original sketch, creased and worn, held together with tracing cloth, and bearing upon its back the date and time, "2 p.m."
After Mr. Wright's death it came into the possession of his daughter, was presented by her to me, and is now presented by me to the Museum of Science and Industry.
F. R. Low
Passaic, N. J.
March 20, 1931.

FIG. 1 FROM A PHOTOGRAPH OF THE SKETCH OF THE "CORLISS" VALVE, MADE APRIL 17, 1849, BY WILLIAM WRIGHT, AND PRESENTED TO THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY BY DR. FRED R. LOW

I am sure that they would be pleased if a place may be found for it in the Museum, where it may be preserved and accessible to those who may be interested.

There can be no doubt that Mr. Wright made this sketch and on the date given. The idea shown may have been wholly Mr. Wright's, as is implied in his conversation with Dr. Low, or possibly have been developed jointly during the conversa-

[3] Special Instructor, School of Technology, The College of the City of New York.

tion. We never can know. It seems certain that Mr. Wright made some contribution to this valuable invention, although it is known in history only under Corliss's name, and it is only fair to Mr. Wright that this incident and this sketch be known.

JOSEPH W. ROE.[4]

New York, N. Y.

Engineer or Clerk?

TO THE EDITOR:

Over a period of years, we all have heard many practising engineers comment on the relative value of $20, or membership in the professional societies. Too many have discontinued membership because they "get nothing out of it." Those "professionally minded" drop the hint that we take from anything in proportion to what we put into it.

The answer to all this is peculiarly evident in these days of unemployment. Merely joining a professional society does not guarantee a man's holding his job. But there is a conspicuous coincidence between engineers who are working, and those who are members of the societies. This can only reflect the men's attitude toward their chosen lifework. They consider themselves professional men, and take their profession seriously. Of course, it would be unjust to say that men not members of the professional societies are less likely to be professionally minded. Nevertheless, it is noticeable in talking with hundreds of unemployed engineers, that too many have been in the position of a technical clerkship, following orders from laymen who know nothing of technical matters, and yet as technical men being held responsible for results. They are not affiliated with the great professional societies which are unceasingly working toward strengthening the position of the technical engineer. Their employers honor their legal advisors, their physicians, their certified public accountants. They do so because these professional gentlemen are professional, they are members of their bar associations, their medical societies, their accountants' organizations—they are recognized in law as authoritative specialists whose judgment in their specialty is accepted as final and decisive in legal testimony.

Members of engineering societies need not be told how their societies function. But very often these members could greatly help the unaffiliated engineers by explaining to them the advantages of affiliation, and steering them. Every society member should consider himself as on the membership committee and try to induce every technical man to display in his office his certificate of membership in his professional society, and to defend his professional position, and, in turn, assist others. Some employers who are loyal members of their professional societies are unaware that their subordinates are adding men to their staff through commercial employment agencies, instead of assisting one of the most worthy endeavors of their societies, the Engineering Societies Employment Service, and are themselves obtaining men who also consider their professional status in their own membership. Furthermore, from an economic standpoint, supervising the selection of their staff from the Engineering Societies Employment Service will assist fellow members to avoid the high fees levied by commercial agencies. Employment may be a detail in administration, but the character of personnel, after all, makes the character of the organization, and members in positions of responsibility can do much to raise the status of their professional brethren, and at the same time help their own organization, and their societies, by making professional standing something to be sought.

Experience in trying to find jobs for several hundred technical engineers within the metropolitan area, and cooperating with the employment organizations of the societies, covering members and non-members, proves that most unaffiliated engineers express great regret at their own negligence in better years, for not having accepted the advantages of organization, especially evident in times like the present. If these engineers live up to their present threats, the societies will be greatly augmented when these men once more have money. Meanwhile, they stand in the position of the lost. They recognize themselves as technical clerks, without standing, and often are so apologetic about it as to be pitiable. Of the unemployed technical men registered in this particular office, comparatively few are members of the societies.

From the viewpoint of the employment office, there is an increasing tendency for employers to engage technical men who are professionally affiliated. Others are apt to be relegated to clerkships. It is logical. They do this with their lawyers and doctors. Engineers or clerks? The distinction is defined by professional attitude.

JOHN H. R. ARMS.[5]

Orange, N. J.

[4] Professor of Industrial Engineering, New York University. Mem. A.S.M.E.

[5] Special Agent, Employment Service, U. S. Department of Labor. Mem. A.S.M.E.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 749 (Reopened), 751, and 754 (Reopened), as formulated at the meeting of May 26, 1933, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 749 (Reopened)

Inquiry: Do not the provisions of Par. U-77, which require hydrostatic testing of all welded pressure vessels, conflict with those of Par. U-64, which provide for testing by air pressure if the size is too great for the foundations to withstand the weight of the water used in testing?

Reply: It was the intent in the revision of Par. U-64 to make an exception of large riveted vessels for gas-storage purposes. To provide for this it is proposed to revise Par. U-64 as follows:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure of not less than $1\frac{1}{2}$ times the maximum allowable working pressure except that for enameled vessels including those of welded construction, the test pressure shall be at

least, but need not exceed the working pressure and excepting other fusion welded vessels which shall be tested in accordance with Par. U-77.

Gas storage vessels of riveted construction which are so constructed or installed as not to be capable of safely withstanding the weight of the large mass of water required to fill them for hydrostatic test, may be tested by compressed air to a pressure of at least, but which need not exceed, the maximum allowable working pressure of the vessel, provided the allowable working pressure does not exceed 80 per cent of that which would be permitted if the vessel were subjected to the regular hydrostatic test pressure.

CASE NO. 751

Inquiry: The welding specifications for both power boilers and Class 1 unfired pressure vessels require two test plates to be made for each vessel. It is not specified by whom such test plates should be made, nor is there any reference made to the qualification of welders if several are employed on the fabrication of any particular vessel. Please clarify the intent of the Boiler Code Committee as regards the qualifications of welders engaged in Class 1 and power boiler welded construction.

Reply: It is the intent of the Boiler Code Committee that in fusion welding for power boilers and Class 1 unfired pressure vessels, where several welders are employed on one vessel, the manufacturer shall satisfy the inspector that all of these welders have proved their ability to comply with the requirements for Class 1 construction by previously conducted tests. It is the duty of the inspector to satisfy himself that only welders who are proved competent by these tests are used to weld any pressure part of the vessel and that all welding complies with the Code requirements. To enable the inspector to perform this function, he shall be permitted to observe all the welding operations on said vessel. The inspector has the right at any time to call for and witness the making of test specimens by any welder and to observe the physical tests to satisfy himself that this welder has the necessary ability to comply with these requirements. When more than one welder is employed on a power boiler drum or a Class 1 unfired pressure vessel, the intent of the Boiler Code Committee will be fully met if the test plates are made by one of these welders, but it is the opinion of the Committee that the inspector may designate which welder shall make the test plates.

CASE NO. 754 (Reopened)

Inquiry: When there are a number of vessels of substantially identical dimensions and of the same grade of material being fabricated by welding, would it be permissible under Par. P-102*b* of the Code to furnish two test specimens for a given length of welded joint?

Reply: The Boiler Code Committee recommends that when there are several vessels being welded in succession on any one order whose plate thicknesses fall within a range of $^1/_4$ in. and whose diameters differ by not more than 6 in., and of the same grade of material, the provisions of Par. P-102*b* be considered as being complied with, if two test plates are furnished for each 50 lineal feet of either or both longitudinal and girth joints, provided the joints are made by the same welders and by the same method of welding.

BOOK REVIEWS

Engineering Shop Practice

ENGINEERING SHOP PRACTICE. By Prof. O. W. Boston, B.M.E., M.S.E. John Wiley & Sons, Inc., New York, N. Y., 1933. Cloth, 539 pp., $5^1/_2 \times 9$ in., 438 illus., $5.50.

REVIEWED BY A. L. DE LEEUW[1]

THIS book, of which the first volume has just appeared and of which a second volume is promised, is clearly intended to be used as a textbook for engineering students. The author himself says so in his preface. However, this should not be construed as meaning that nobody else could profit by it.

There is much material which is valuable to the engineer long past his student years and of equal value to shop executives. Formulas for cutting pressure, tabulations, and charts are presented which should be of value to the constructor of machine tools as well as to those who use these machines. Many of these formulas are the results of recent experimentation by Professor Boston and his associates and have been the subject of a number of papers before The American Society of Mechanical Engineers. The results obtained by other experimenters of recent as well as of older days are also included.

It is true that such data can be obtained by scanning the proceedings of The American Society of Mechanical Engineers and other sources, but the average man does not avail himself of such possibilities unless they are assembled in book form. Professor Boston has given us a book in which the latest knowledge is presented. Such knowledge, in the nature of things, cannot be final, and it is to be hoped that the author has made plans to include in future editions of his book the further developments along the line of knowledge of the art of cutting metals.

The book is full of illustrations of existing machine tools. A great many of these could have been omitted without lessening the value of the book. Most of them are plates taken from photographs. As is generally the case, such illustrations tell very little and are a disappointment to the man who looks at them for the purpose of finding out how the machine tools are constructed or what he can do with them. It would seem that it would be more instructive to have one illustration of a certain type of machine and a few line drawings showing the essentials of its construction. Here and there this is done in the book, but it might have been done much more frequently to good advantage.

No mention is made of a number of machine tools which nowadays play a great rôle in our manufacturing operations. It is of course unfair to speak of this omission as if it were a criticism, for these things may appear in the second volume. Additional machining operations are promised. It may well be that among these we shall find grinding machines, gear-cutting machines, turret lathes, automatic screw machines, automatic chucking machines, broaching machines, power presses, and others. If all of these are not to be included in the second volume, this omission may be considered a serious lack, for a great part of our present manufacturing methods depends on just these machines.

There is another thing which might have been included in

[1] Consulting Engineer, Plainfield, N. J. Mem. A.S.M.E.

the present book, even if some parts would have had to be omitted to make place for it. The "history and development" of the various machines is of such a schematic nature that the pages so occupied could have been used to better advantage, though the machines are interesting enough in themselves. In their place, something might have been given to open the eyes of the student to possible future developments. These students are supposed to be the future leaders in the industry, and it should not be enough that they merely know what *is;* they also should have some idea of what *can be* later on.

And in connection with this, it might be pointed out that certain developments which are at the present in the experimental stage should have been given a place in the book. Professor Boston mentions the Klopstock tool and how it originated from some experiments carried out by the writer of this review, but he does not mention the fact that the polished condition of the tool has a material influence on its life, and this is a thing which holds good not only for this particular type of tool but for all tools.

Practically no mention is made of the effect of stream lubrication on the speed of milling cutters. It is true that the present construction of milling machines does not always lend itself to the application of this system, but it is just for this reason that it should be included, so as to call the student's attention to a possible improvement in milling machines making this system applicable.

A few other points of the same nature might be mentioned. In defense of such omissions it might be said that textbooks as a whole merely state the conditions as they are, but, this being true, it also is true that textbooks should not be that way.

All in all, the book is a valuable and much-needed addition to the literature on machine tools and should be in the hands of every student and executive dealing with machine-shop operations.

Vibration Prevention in Engineering

VIBRATION PREVENTION IN ENGINEERING. By A. L. Kimball. John Wiley & Sons, Inc., New York, 1932. Cloth, 6 × 9 in., 145 pp., $2.50.

REVIEWED BY J. ORMONDROYD[2]

MR. KIMBALL has given in 140 pages a brief résumé of the various aspects of vibration prevention. The material is condensed and selected from the author's personal engineering experience, and contains, in his opinion, all that is necessary for handling effectively the usual vibration problems. This condensation has made it necessary to omit long analytical developments and detailed discussions of results. It is written for the practising engineer who desires to use the results without studying the subject in logical completeness. Subjects such as the laws of similarity for vibrating bodies, the principle of superposition of small motions, and harmonic analysis receive only passing mention.

The book can be divided into two main parts: Chapters 1 to 8, excluding chapter 6, are devoted to the development of the usual classical theory of small motions in systems with lumped mass, flexibility, and damping. Chapters 9 to 15 treat various special problems of vibration prevention. As an interlude between the two main parts, chapter 6 discusses briefly the flexural and longitudinal vibration of uniform bars in which flexibility and mass are uniformly distributed.

The chapters dealing with the general theory are too short to be entirely logical or complete. The emphasis is laid on rules for practical procedure. The chapter on "Theorems on the Rotation and Translation of Rigid Bodies" is a good example of this.

The outstanding chapter of this section is devoted to practical rules for using complex quantities in the solution of vibration problems. Here the question arises—why can it be said that Equation 44

$$m\frac{d^2y}{dt^2} + b\frac{dy}{dt} + ky = F\cos\omega t \quad [44]$$

can be written as (or is equivalent to) Equation 49

$$m\frac{d^2y}{dt^2} + b\frac{dy}{dt} + ky = Fe^{i\omega t} = F\cos\omega t + Fi\sin\omega t \quad [49]$$

The complex-quantity method saves so much labor that it deserves to be introduced more persuasively. After introducing the method, the author uses it consistently throughout the remainder of the book.

In passing, one might question the author's use of N for the modulus of rigidity when common usage has standardized on the symbol G for this quantity. Moment of inertia is defined as $I = Wr^2$ (weight × radius squared). This quantity is usually called "flywheel effect" in technical circles. The author has invented the term "angular mass" for the quantity Wr^2/g which is the usual mass moment of inertia in the literature of mechanics. As the author has developed the bending equations for beams, his equation $EI\frac{d^2y}{dx^2} = M$ is in reality an identity (the internal moment equals the internal moment). This differs somewhat from the equation actually used in which the internal moment and the externally applied moment are in equilibrium leading to $EI\frac{d^2y}{dx^2} = -M$.

The chief value of the book lies in the excellent chapters on special problems. The chapters on vibration damping and the measurement of "solid" friction describe ingenious experimental methods for measuring and estimating logarithmic decrements of various vibrating systems.

The chapters on turbine-wheel and blade vibrations serve as an excellent introduction to Campbell's classic work on turbine-disk vibration published in the Transactions of the A.S.M.E. in 1924.

The discussions of shaft whirling due to internal friction and oil whip give a glimpse into the broad field of "self-induced" vibrations where the motion is such as to tap the energy for its maintenance from the driving mechanism.

The balancing of rigid rotors is discussed briefly, and the principles of the common balancing machine are presented. The ingenious automatic balancing machine designed by E. F. Thearle of the General Electric Company is described in some detail.

Perhaps the chapter on spring mounting of machinery will have the most practical interest for those who will read this little book. The effect of the interposition of a spring and damping mechanism between the machine and a rigid foundation are discussed first. The author then treats the case where the foundation has finite mass and flexibility. By defining the transmissibility as the ratio between the new amplitude of the foundation and the original amplitude he arrives at a neat and useful formula. The fact that the equivalent mass and flexibility of the original foundation are seldom known does not detract from the usefulness of the formula. Practical advice is given on the use of cork, rubber, and steel as spring members. The author feels that a successful spring mounting

[2] Experimental Division Engineer, Westinghouse Electric & Mfg. Co., Philadelphia, Pa. Mem. A.S.M.E.

demands a ratio of operating speed to resonance speed of at least 7. Although a softer spring gives more cushioning, many successful spring mountings are operating with this ratio as low as 3 and 4.

The Early Years of Modern Civil Engineering

THE EARLY YEARS OF MODERN CIVIL ENGINEERING. By Richard S. Kirby and Philip G. Laurson. Yale University Press, New Haven, Conn., 1932. Cloth, 6 × 9¼ in., 324 pp., illus., $4.

THE spiritual and professional heritage which all engineers, mechanical as well as civil, have received from those stalwarts who laid the foundations of modern civil engineering is gratefully acknowledged by those who have had the interest to inquire into the history of engineering and the biographies of engineers. But, as Professors Kirby and Laurson point out, engineers generally know little of this history or of the men of other days who have made it what it is. Their book, therefore, is a welcome addition to a small but growing list of works in these fields, and should afford a background for the study and practise of engineering that will add to the enthusiasm and respect men have for their profession. It can be read with interest and profit, and is a valuable reference volume for every engineer's library.

In the performance of routine practices, engineers are apt to forget that instruments and methods are the result of long, painstaking development. Even a mediocre apprentice may satisfactorily perform tasks that seemed difficult or were impossible to perform before the genius of these great engineers provided, step by step, the instruments, the technique, and the accumulated theory and data that are so readily available today. But the men whose names and accomplishments fill this excellently illustrated and carefully documented book were engineers in the truest sense, the men who perform the task for the first time.

Surveying, canals, roads and pavements, railroads, bridges, tunnels and subways, waterworks and water power, sewers, river and harbor improvement, and materials form the natural divisions of this record, which covers, in general, the eighteenth and early nineteenth centuries. In addition there are to be found biographical outlines of more than one hundred eminent engineers. Appendixes to the individual chapters and to the book provide selected bibliographies.—G. A. S.

The Alloys of Iron and Molybdenum

THE ALLOYS OF IRON AND MOLYBDENUM. By J. L. Gregg. Published for The Engineering Foundation by the McGraw-Hill Book Company, Inc., New York, 1932. Cloth, 6 × 9 in., 507 pp., 154 figs., $6.

REVIEWED BY J. P. GILL[3]

THIS book, essentially a compilation of all available information on the alloys of iron and molybdenum, will be found of value as a reference for any one interested in the subject. It is the first of a series to be published on the alloys of iron. The purpose of the book is explained in the introduction as a collection in readily accessible and usable form of the important known facts in regard to molybdenum steels and the other alloys of molybdenum iron with or without additional alloying elements.

The book is well arranged and indexed so that any desired information on the subject may be found readily. The source of all information is clearly shown so that the reader may, if he wishes, refer to the original.

The information and data given have been carefully weighed by the author so that there appears a minimum of what might be considered unreliable or inaccurate data. On the other hand, where there is conflicting information which could not be differentiated, both have been stated.

The book is composed of eleven chapters with an extended bibliography. It is amply filled with micrographs, diagrams, and tables. It is a necessary addition to even the smallest library of books on ferrous metallurgy.

[3] Metallurgist, Vanadium-Alloys Steel Company, Latrobe, Pa.

Lasting Prosperity

LASTING PROSPERITY. By A. G. McGregor. Isaac Pitman & Sons, New York, 1933. Cloth, 5¼ × 8¼ in., 151 pp., 2 figs., $2.25.

REVIEWED BY L. P. ALFORD[4]

THIS book is given over to an exposition of "credit currency" and arguments for its adoption. It offers a remedy for business depression which, in the author's opinion, is not only a cure-all, but a permanent cure-all. All such single remedies seem to be based on a kind of thinking that overlooks the great complexity of the forces that produce booms, on the one hand, and the multiplicity of the causes of depression, on the other.

"The one great essential to continuous prosperity in an industrial nation," the author declares to be, "the maintenance of a balance between the power to consume and the power to produce." This is said to be impossible under the gold standard.

The measures necessary to be taken to bring lasting prosperity are:

(*a*) Abandon the gold standard.

(*b*) Impose no limit on the amount of credit currency issued against sound collateral.

(*c*) Regulate the purchasing power in home markets by regulation of general wage and salary levels by government decree.

(*d*) Control the purchasing power of currency in foreign markets by regulating the exchange rate. Commodities are to be used as a basis for regulating the purchasing power of banknote currency issued under this plan. The author suggests a list and indicates weightings approximately in the proportion to the amounts consumed in Great Britain: 200 lb of sugar, 2000 lb of flour, 250 lb of beef, 100 lb of pork, 25 lb of cod fish, 50 lb of salt, 50 lb of butter, 15 bu of potatoes, 250 lb of beans, 6 doz oranges, 6 doz bananas, 1 bbl of apples, 50 gal of milk, 50 lb of wool, 150 lb of cotton, 25 lb of linen, 10 tons of coal, ½ ton of pig iron, 50 lb of copper, 25 lb of lead, 10 lb of aluminum, 500 common red brick, 500 lb of cement, 100 lb of lime, 500 fbm of lumber, 1000 lb of newsprint, 100 lb of rubber, etc., etc.

"Credit currency," so the author believes, has "the possibility of becoming one of the greatest aids to the material well-being of mankind ever invented." High wages, high salaries, active business, high efficiency in producing goods, high effectiveness in distribution, and equity in the allocating of the fruits of industry between capital and labor—all these will follow its adoption.

While credit currency is a useful business tool, and has been frequently made use of, it is difficult to imagine that a single monetary device when applied will cure all our economic ills and bring "lasting prosperity."

[4] Vice-President, The Ronald Press Company, New York, N. Y. Mem. A.S.M.E.

Books Received in the Library

AIRCRAFT YEAR BOOK for 1933. Compiled by Aeronautical Chamber of Commerce. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 506 pp., illus., diagrams, charts, maps, tables, $6. This volume provides a comprehensive record for ready reference of the aircraft industry. An extensive review of the developments of the past year, covering commercial, manufacturing, and engineering progress, occupies the major portion of the book. The present records of all kinds are given in full, as well as much statistical data upon production, sales, operations, etc. There is also an aeronautical directory. The work is excellently adapted to answer most frequently recurring questions.

ATM—Archiv für Technisches Messen. Nos. 19 and 20, January and February, 1933. R. Oldenbourg, Munich and Berlin. Paper, 9 × 12 in., pp. 1–30, illus., diagrams, charts, tables, 1.50 rm. each. Colorimetric hydrogen-ion determinations, the measurement of losses in mercury rectifiers, recording devices for instruments, watch movements, liquid gages, thermo-elements, and various other methods of measurement are discussed in numbers 19 and 20 of this handbook. The articles are concise summaries by experts.

DAVISON'S SILK AND RAYON TRADES, 38th, 1933 pocket edition. Davison Publishing Co., New York, 1933. Cloth, 5 × 7 in., 588 pp., $5. Geographic and classified lists of the silk mills and dyeing and finishing plants of North America are given, with information as to their owners, equipment, capacity, etc. In addition lists are given of textile designers, commission merchants, and others associated with the industry. The directory covers thoroughly this important branch of the textile industry.

THE ELDER PLINY'S CHAPTERS ON CHEMICAL SUBJECTS, Part 2. Edited with translation and notes by K. C. Bailey. E. Arnold & Co., London, 1932. Cloth, 6 × 10 in., 299 pp., $5. Dr. Bailey, a well-known Irish chemist, has for eight years been occupied with the translation of the distinctively chemical portions of Pliny's "Natural History," which is completed with the publication of this volume. A carefully edited text and a good translation, accompanied by copious notes, are now available for the first time to students of the history of the science of the Romans.

ELEMENTS OF INDUSTRIAL HEAT. Vol. 1. By J. A. Randall and J. W. Gillon. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 261 pp., illus., diagrams, charts, tables, $2.75. The fundamentals of heat engineering are presented with a minimum of mathematical discussion and in as simple language as the subject will permit in this text-book. The fundamental concepts, calorimetry, expansion and changes of state caused by heat, heat transmission, fuels and combustion, air, and humidity are discussed in the first eight chapters, and there is a final chapter on the elements of thermodynamics. The book is adapted to home study, as well as class use.

EXPERIMENTAL ATOMIC PHYSICS. By G. P. Harnwell and J. J. Livingood. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 472 pp., illus., diagrams, charts, tables, $5. In this introduction to atomic physics, the object has been to develop logically the theories of radiation and matter, with particular attention to fundamental conceptions and their experimental foundations. Experiments demonstrating these basic principles are incorporated in the text, with sufficient detail for the preparation of the apparatus. The book is based upon a course given to seniors and first-year graduate students at Princeton University.

GLASS FACTORY YEAR BOOK AND DIRECTORY, 1933 edition. American Glass Review, Pittsburgh, Pa. Leather, 5 × 8 in., 120 pp., tables, $3. List of glass factories of the United States, with the names of officers, equipment, and products. The arrangement is by types of products, with a geographical index. Production statistics, trade and labor organizations, and other data are included.

INTRODUCTION TO THEORETICAL PHYSICS. 5 Vols. By M. Planck, translated by H. L. Brose. Macmillan & Co., London and New York, 1932–1933. Cloth, 5 × 9 in., diagrams, tables. Vol. 1, General Mechanics, 272 pp., $2.50; vol. 2, Mechanics of Deformable Bodies, 234 pp., $2.50; vol. 3, Theory of Electricity and Magnetism, 247 pp., $2.50; vol. 4, Theory of Light, 216 pp., $2.50; vol. 5, Theory of Heat, 301 pp., $2.75. This course in theoretical physics is intended for mature students acquainted with analytic geometry and the infinitesimal calculus, and aims to prepare them for the exhaustive treatises and the detailed special literature. Having found through experience that the difficulties of beginners are with the physical content of the ideas presented, rather than with their mathematical form, Professor Planck gives special attention to the setting up of the equations and especially to their interpretation. The treatment is predominatingly deductive. Professor Brose's translation is thorough and the book will be welcomed by English-speaking students.

LOCOMOTIVE BREAKDOWNS AND APPLIANCES. By C. A. Cavey and J. W. Harding. International Textbook Co., Scranton, 1932. Leather, 5 × 8 in., 86 pp., illus., diagrams, $1.40. The first section of this work describes the correct handling of breakdowns during service. The second part describes the construction and use of safety valves, whistles, sanders, reverse gears, and other locomotive appliances. The text is brief and practical.

DIE LUFTSPEICHER-DIESELMASCHINE. (Stand der Technik.) By B. Klaften. Carl Heymanns Verlag, Berlin, 1932. Cloth, 6 × 9 in., 179 pp., illus., diagrams, charts, tables, 14 rm. The present development of the type of Diesel engine which utilizes an air reservoir is carefully described in this monograph, which deals with its theory and the designs that have appeared prior to October, 1932. The book has been prepared by the examiner in charge of this class in the German Patent Office and is based upon the patents and other literature available there. It is a useful review of the "state of art," of interest to designers and inventors. References to the literature and patents are given.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS. Vol. 2, No. 5, March, 1933. V.D.I. Verlag, Berlin. Paper, 8 × 12 in. pp. 99–134, illus., charts, diagrams, tables, 4 rm. Contains articles upon notch testing of weld steel and cupola operation in melting high-grade gray pig-iron.

MITTEILUNGEN DES HYDRAULISCHEN INSTITUTS DER TECHNISCHEN HOCHSCHULE MÜNCHEN, No. 6. Edited by D. Thoma. R. Oldenbourg, Munich and Berlin, 1933. Paper, 8 × 11 in., 60 pp., illus., diagrams, charts, tables, 4.20 rm. Of the four articles here published, three deal with the Gibson method for measuring the flow of water in conduits. Two of these describe the development of a photography pressure recorder of greater exactitude than former ones. In the third article Dr. Thoma discusses the oscillations in flow disclosed by the new recorder. The remaining article describes an investigation of resistance to flow at elbows in open channels.

PRINCIPLES OF RADIO COMMUNICATION. By J. H. Morecroft, assisted by A. Pinto and W. A. Curry. Third edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 10 in., 1084 pp., illus., diagrams, charts, tables, $7.50. During the five years that have elapsed since the previous edition of this well-known textbook appeared, many changes have occurred in radio practice. These changes are reflected in this new edition. More information is given on rectifying apparatus and circuits, filters, shielding, and electrolytic condensers. The newer tubes are noticed and the action of piezo-active quartz is explained. Throughout the text much new material has been introduced, and obsolete data have been deleted.

PROFIT ENGINEERING. By C. E. Knoeppel and others. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 326 pp., diagrams, charts, tables, $3. The theme of this book is that a business, to remain solvent, must make profits, rather than volume, its goal. To accomplish this sales income and cost outgo must be planned and controlled, as production is. The author presents a plan for doing this and explains the use of his "Profitgraph."

RECENT SOCIAL TRENDS MONOGRAPHS. McGraw-Hill Book Co., New York, 1933. Cloth, 6 × 9 in. Americans at Play, by J. F. Steiner. 201 pp., $2.50. Arts in American Life, by F. P. Keppel and R. L. Duffus, 227 pp., $2.50. Metropolitan Community, by R. D. McKenzie. 352 pp., $3.50. Problems of Education in the United States, by C. H. Judd, 214 pp., $2.50. Rural Social Trends, by E. S. Brunner and J. H. Kolb, 386 pp., $4. Trends in Public Administration, by L. D. White, 365 pp., $4. The report on "Recent Social Trends in the United States," recently issued by the President's Research Committee, is supplemented in various directions by these six monographs. They record, in extended and detailed form, the scientific and statistical data assembled for the Committee and discuss the findings more fully.

ROYAL TECHNICAL COLLEGE JOURNAL, Glasgow. Vol. 3, Part 1, January, 1933. Paper, 7 × 10 in., 199 pp., diagrams, charts, illus., tables, 10s. 6d. This volume records some of the research work done at the College during the past year, chiefly in physics, chemistry, and engineering. Among the papers of interest to engineers are investigations of the corrosion of lead, the transmission of heat from honeycomb radia-

tors, heat transmission to and from tubes perpendicular to an air flow, the influence of roughness of surface and variation of speed on boundary lubrication, engine-damping factors in torsional oscillation and the effect of vibration form, direct and bending stresses in cylindrical and conical thin walls, the measurement of peak voltages, power-factor improvement for industrial loads, and the sparking of coal-cutter pick tool steel in explosive firedamp mixtures.

DAS SCHWIMMLAGER, Hydrodynamische Theorie des Gleitlagers, By W. Stieber. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 8 in., 106 pp., charts, tables, 8 × 6 in., 6.15 rm. As the application of the hydrodynamic theory of lubrication to the design of journal bearings has included several arbitrary assumptions regarding pressure conditions at the ends of the bearings, Dr. Stieber has undertaken to provide a more accurate basis for the theory. Methods are developed for determining the load and coefficient of friction for full and partial bearings, and their use in calculation explained. Lines for further study of the theory are indicated.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES, Extracts from Vols. 8 and 9 (1927–1929). Données Numériques d'Electricité Magnétisme et Électrochimie, by P. Auger, L. Durand and others, $7.84. Art de l'Ingénieur et Métallurgie, by L. Descroix. Gauthier Villars et Cie., Paris; McGraw-Hill Book Co., New York, 1932. Paper, 9 × 11 in., diagrams, charts, tables, 11 × 9 in., paper, $4.70. The International Critical Tables were largely based upon the original experimental values contained in the first seven volumes of the Annual Tables of Constants and Numerical Data. Succeeding volumes of the latter form an essential supplement to the Critical Tables, by supplying additional and better data as they appear.

In addition to the complete annual edition, extracts are published for the benefit of those interested only in certain fields of work. The present volumes cover the needs of workers in electricity and electrochemistry, in mechanical engineering, and metallurgy. The text is in English as well as French.

TECHNISCHE MESSUNGEN. (Maschinentechnisches Versuchswesen Vol. 1.) By A. Gramberg. Sixth edition. Julius Springer, Berlin, 1933. Cloth, 6 × 10 in., 488 pp., illus., diagrams, charts, tables, 24 rm. A concise review of methods of measurement for use in mechanical laboratories and in practical work. The properties of measuring instruments and methods of observing are first discussed, after which the construction and use of the customary instruments are described in detail. Measurements of pressure, time, velocity, weight, volume, work, temperature, etc., are considered, and there are chapters on calorimetry and gas analysis. There is a useful bibliography.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS, Twenty-Third Edition. 1932–33. Thomas Publishing Co., New York. Cloth, 9 × 12 in., illus., $15. This directory is so well known to buyers and purchasing agents that announcement of the new edition is sufficient. Practically every manufactured product is included, with the names of the makers. A directory of manufacturers gives home and branch-office address. A list of trade names identifies the makers of branded goods. Minor lists include representative banks and commercial organizations throughout the United States.

WORLD SOCIAL ECONOMIC PLANNING—The Necessity for Planned Adjustment of Productive Capacity and Standards of Living. Two volumes. International Industrial Relations Institute, The Hague, Holland; also Room 600, 130 East 22nd St., New York, 1932. Cloth, 6 × 10 in., 935 pp., diagrams, charts, tables, $2.50. These volumes contain the papers and discussions presented at the Congress held in Amsterdam in 1931, at which the necessity for planned adjustment of productive capacity and standards of living was discussed by a group of economists and sociologists representing many countries. The paradox of unemployment in the midst of economic progress, the principles and practicability of economic planning, experience in national economic planning and the necessity and means for it, and standards of living as the resultant of productive capacity and buying power were the main heads of the discussion.

ZUSCHLAGERMITTLUNG IN DER MASSENFABRIKATION FÜR FREIE UND GEBUNDENE HANDARBEIT. (Berichte über betriebswissenschaftliche Arbeiten, Bd. 9.) By R. Engel. V.D.I. Verlag, Berlin, 1932. Paper, 8 × 12 in., 23 pp., illus., diagrams, charts, tables, 4.10 rm. This investigation is concerned with time requirements for operations with very short base times, such as are the rule with hand-work in mass production, and especially with the determination of the allowances which must be made for lost time. Rules for time studies of very short operation are discussed, the results of studies in various factories and of laboratory tests are given, and conclusions of general usefulness drawn.

WHAT'S GOING ON

Nominations for Officers of A.S.M.E., 1933-34

AT THE Semi-Annual Meeting of The American Society of Mechanical Engineers, held at Chicago, Ill., during Engineering Week, June 25 to July 1, the Nominating Committee reported the following nominations for officers for 1933–34, to be voted on by letter ballot in the early fall:

For president, Paul Doty; for vice-presidents, William L. Batt, H. L. Doolittle, Ely C. Hutchinson, and Elliott H. Whitlock; and for managers, James A. Hall, Ernest L. Ohle, and James M. Todd. Brief biographical sketches of the nominees follow:

Paul Doty

PAUL DOTY, nominated for the office of President of The American Society of Mechanical Engineers, is chairman of the Minnesota State Board of Registration for Architects, Engineers, and Land Surveyors. He was born in Hoboken, N. J., on May 30, 1869. His first American ancestor was Edward Doty, a Pilgrim passenger in the *Mayflower*, and Mr. Doty has served as Deputy Governor General of the Society of Mayflower Descendants and also as Governor of the Society of Colonial Wars in Minnesota.

Upon being graduated from Stevens Institute of Technology in 1888 with the degree of Mechanical Engineer, Mr. Doty entered the gas industry, with which he has been identified most of his life. His first service, in 1888, was with the late Dr. Alexander C. Humphreys, of The United Gas Improvement Company. In 1895, Mr. Doty became associated with the late Emerson McMillin, of the American Light and Traction Company, New York. Mr. Doty was vice-president and general manager of the Consolidated Gas Company of New Jersey from 1895 to 1898, when he became secretary and general manager of the Grand Rapids (Michigan) Gas Light Company from 1898 to 1901. While in Grand Rapids, Mr. Doty was a director of the National City Bank of Grand Rapids. From 1901 to 1903 he was secretary and general manager of the Detroit City Gas Company. In Michigan, he was president of the Michigan Gas Association, and was actively interested in establishing the first gas scholarship course at the University of Michigan. At this time also he was president of the Detroit Suburban Gas Company, and president of the Wyandotte Gas and Fuel Company. In 1903 and 1904 he was vice-president and general manager of the Denver Gas and Electric Company. In 1904 he became vice-president and general manager of the St. Paul Gas Light Company, the Edison Electric Light and Power Company, the St. Croix Power Company, and later the So. St. Paul Gas and Electric Company. He was president of the Union Light, Heat, and Power Company, of Fargo, North Dakota, from 1905 to 1910. In 1906, he served as president of the Western Gas Association, and also as president of the McMillin Gas and Electric Companies Association. Mr. Doty was with the McMillin interests until 1917, when he entered the service of the United States in the World War.

Mr. Doty served as Major, Corps of Engineers, U.S.A., 1917 to 1919; as Utilities Officer, Camp Grant, Illinois, 86th Division, 1917; Officer in Charge of Utilities, Wash-

ington, D. C., 1918, for all camps and cantonments in the United States; and was detailed as a member of the General Staff Corps, U. S. A., 1919, to advise and to recommend to the Secretary of War on the construction projects for the U. S. Army. In 1919, he was commissioned Lieutenant-Colonel, U. S. Corps of Engineers, and is now a Lieutenant-Colonel of the Reserve Corps of the U. S. Army. Mr. Doty has also served as Brigadier-General, General Staff Corps, Minnesota National Guard.

In 1910, Mr. Doty was president of the Business League of St. Paul, and in 1923 he was named president of the St. Paul Association of Commerce. At this time he was also vice-president and managing director of the St. Paul Trust and Savings Bank. In 1927, he was made president of the National Council of State Boards of Engineering Examiners. He is registered professional engineer No. 1 in the State of Minnesota, and has served continuously as chairman of the State Board of Registration since its organization in 1921. He has been actively engaged as advisory engineer to St. Paul financial institutions, particularly in the line of public utilities, in which he has important interests. He has contributed a number of technical papers to the various gas associations with which he has been identified.

Mr. Doty became a junior member of the A.S.M.E. in 1891, and a member in 1904. He has served as chairman of the Committee on Local Sections, and as a Manager of the Society, and also as Vice-President. He now represents the Society on the American Engineering Council, and is chairman of the Council's Committee on Engineers and Employment. He is a member of the American Institute of Electrical Engineers, the Society of American Military Engineers, and an honorary member of the University of Minnesota chapter of Pi Tau Sigma.

Mr. Doty is well known personally to the members of the Society through his activity in its social as well as business affairs. He is married, and has one daughter. His home is at 427 Portland Avenue, St. Paul, Minn.

William L. Batt

WILLIAM L. BATT, nominated for the office of Vice-President of The American Society of Mechanical Engineers, is president of the SKF Industries, Inc. Mr. Batt was born in Salem, Ind., in 1885. His family later moved to Lafayette, where he attended the public schools, and eventually Purdue University, from which he was graduated in 1907 in mechanical engineering.

Shortly after his graduation he became associated with the Hess-Bright Manufacturing Company, Philadelphia, in manufacturing, engineering, and sales of anti-friction bearings. In 1917 he became general manager of the company, and following the consolidation of the SKF Ball Bearing Company, Hess-Bright Manufacturing Company, and other organizations, became vice-president of SKF Industries, Inc., the central organization. He has held the office of president since 1922. Mr. Batt is also chairman of the Board of Directors of the Air Preheater Corporation and a director of the Hudson Insurance Company, New York.

Mr. Batt has been a member of The American Society of Mechanical Engineers since 1911, and has been actively interested in its work, serving as chairman of the Revenue Committee, chairman of the Committee on Meetings and Programs, chairman of the Coordination Committee of Engineering Societies, U.E.T., Inc., and as a member of the Market Analysis Committee and of the Committee on Awards. He is at present a Manager of the Society. He is also interested in committee work in the Society of Automotive Engineers.

In 1923 he was elected a member of the Board of Directors of the Swedish Chamber of Commerce of the U.S.A., and in 1926 was elected vice-president. For his interest and activity in promoting commercial relations with Sweden, King Gustav V of Sweden, in 1926, conferred upon Mr. Batt the decoration of the Order of Vada.

He is a member of the Tau Beta Phi honorary fraternity, the Purdue Club of New York, the Engineers' Club, New York, the Upper Montclair Country Club, and the Pine Valley Golf Club. He has contributed numerous articles to technical and general publications.

Harold L. Doolittle

HAROLD L. DOOLITTLE, nominated for the office of Vice-President of The American Society of Mechanical Engineers, is chief designing engineer of the Southern California Edison Company. He was graduated from Cornell University with the degree of Mechanical Engineer in 1906. After spending three years in a variety of design work in Los Angeles, he entered the employ of the Edison Company as draftsman and designer. He was assistant construction engineer for fourteen years, and has occupied his present position for the last seven years. Mr. Doolittle, chairman of the Los Angeles Section in 1921, became a junior member of The American Society of Mechanical Engineers in 1910, and advanced to full membership in 1916. He has been active in the affairs of the A.S.M.E. Hydraulic Division, serving on its executive committee, and is at present a Manager of the Society. He is also a member of the American Society of Civil Engineers.

Ely C. Hutchinson

ELY C. HUTCHINSON, nominated for the office of Vice-President of The American Society of Mechanical Engineers, is president of the Edge Moor Iron Company, Edge Moor, Del. Mr. Hutchinson was born in San Francisco in 1882. In 1898 he entered the employ of the Union Iron Works of that city, builders of the battleship *Oregon*, which earned fame during the Spanish-American War, and of many other ships for the United States Navy and the merchant marine. While working in the pattern shop and drafting room, he pursued his technical studies. In 1903, after returning from a period of field construction and engineering experience in British Columbia, he became assistant manager of the mining department of the works in San Francisco.

About a year after the fire in San Francisco he became associated with the Power and Mining Machinery Company, Cudahy, Wis., as its Pacific Coast representative. Recognizing, however, the coming importance of hydraulic engineering and the use of water power on the Pacific Coast, he associated himself, in 1908, with the Pelton Water Wheel Company, San Francisco and New York, as sales engineer. He continued in this work, handling engineering and sales matters which called him to many parts of this and foreign countries. He became sales manager of the company in 1911, vice-president and general manager in 1922, and president and general manager in 1926. From 1929 to 1933 Mr. Hutchinson served as editor of *Power*, a McGraw-Hill publication, resigning early in 1933 to become president of the Edge Moor Iron Company.

Mr. Hutchinson has been actively associated with most of the major power developments on the Pacific Coast and a number of those abroad and in South America. He has written widely upon steam, hydraulics, and other technical subjects, and has received patents upon hydropower and other machinery.

He is a member of The American Society of Mechanical Engineers and American Society of Civil Engineers; the Engineers' Club of New York, of Philadelphia, and of San Francisco; past-chairman of the A.S.M.E. San Francisco Section; past-president, Engineers' Club of San Francisco; has held a number of important committee positions and chairmanships in the A.S.M.E. in the past, and is at present a member of the A.S.M.E. Standing Committee on Power Test Codes, chairman of Power Test Code Committee for Hydraulic Prime Movers, chairman A.S.M.E. Pure Air Committee, member of the Meetings and Program Committee, member of the Freeman Scholarship Committee, director of Secretariat, Hydraulic Turbines, U. S. National Committee, I.E.C., and a member of the American Committee of the World Power Conference. From 1928 to 1931 he served as a Manager of the Society.

Elliott H. Whitlock

ELLIOTT H. WHITLOCK, nominated for the office of Vice-President of The American Society of Mechanical Engineers, is a partner in the Whitlock Manufacturing Company, Cleveland, Ohio. He was graduated from Texas Agricultural and Mechanical College in 1886, and from Stevens Institute of Technology in 1890 with the degree of Mechanical Engineer. In 1933, he was awarded the honorary degree of Master of Science from Stevens.

Upon his graduation, Mr. Whitlock served as a special apprentice in the shops of the Pennsylvania Railroad at Columbus, Ohio, and then spent considerable time on the layout, construction, and operation of gas plants. For eighteen years he was associated with the National Carbon Company, engaged largely in production and serving as factory manager for several of their plants. His next experience was with cement-manufacturing plants, and

Nominated for
A.S.M.E. OFFICERS IN 1934

For President

PAUL DOTY

For Vice-Presidents

W. L. BATT

H. L. DOOLITTLE

E. C. HUTCHINSON

E. H. WHITLOCK

PAUL DOTY

For Managers

J. A. HALL

E. L. OHLE

J. M. TODD

Biographical sketches of the candidates will be found on pages 523–526 of this issue.

E. H. WHITLOCK

E. C. HUTCHINSON

W. L. BATT

H. L. DOOLITTLE

J. A. HALL

J. M. TODD

E. L. OHLE

later he served as manager of a plant in which a heavy deposit of fireclay was immediately overlaid with a four-foot seam of cannel coal. Mr. Whitlock extended the survey map of this mine to show the new entries and runs. For about five and a half years he was smoke commissioner of the City of Cleveland. He acted as representative of the Public Library Board on the work of erecting the new main Public Library Building in Cleveland, Ohio. For the past few years Mr. Whitlock has been professor of research in smoke abatement at Stevens Institute of Technology, where he assisted in organizing a County Smoke Department for Hudson County, N. J., and in framing a local ordinance in which were embodied the latest engineering principles applicable to the combustion of fuels.

Mr. Whitlock was commissioned Major in the Engineer Reserve Officers Corps in February, 1917, and was ordered to active service three months later. He was assigned to the 24th Engineer Regiment and was promoted to the rank of Lieutenant-Colonel. He served sixteen months in France in command of this regiment, later entering the Engineer Officers Reserve Corps with the commission of Colonel. He has been active in the work of the Fifth Corps area. He joined the Ohio National Guard and had command of the 112th Engineer Regiment of the 37th Division, resigning this commission when he left Ohio.

Mr. Whitlock has been a member of The American Society of Mechanical Engineers since 1901, serving as a Manager from 1913 to 1916. He is a past-president of the Cleveland Engineering Society, a member of the Engineers' Club, New York, and of the University Club and Clifton Club, Cleveland.

James A. Hall

JAMES A. HALL, nominated for the office of Manager of The American Society of Mechanical Engineers, is professor of mechanical engineering at Brown University. Born in Berlin, Vermont, in 1888, he attended the public schools of Providence and was graduated from Brown University in 1908 with the degree of A.B. He received the degree of Bachelor of Science in mechanical engineering from the same institution in 1910, remaining as assistant and then instructor in mechanical engineering until 1914, when he became connected with the engineering department of the Link-Belt Company in Philadelphia. The following year he returned to Brown University as assistant professor of mechanical engineering, teaching courses in machine design and industrial management. He became associate professor in 1920, and since 1925 has been professor of mechanical engineering. Professor Hall has also carried on a consulting engineering practice, and since 1926 has been associated with the Brown & Sharpe Manufacturing Company as consulting engineer.

Professor Hall joined the Society in 1912. He was chairman of the Providence Section of the Society in 1922, and a member of the Standing Committee on Local Sections from 1922 to 1926, being chairman the last year. He was a member of the Research Committee on the Cutting and Forming of Metals from 1924 to 1930, and chairman from 1925 to 1927. He was chairman of the Nominating Committee of the Society in 1929, and has been a member of the Committee on Constitution and By-Laws since 1931. Professor Hall is a past-president of the Providence Engineering Society, chairman of the New England Section of the S.P.E.E., a member of the Newcomen Society, and of the Society of Sigma Xi. He is the author of numerous articles published in the technical press.

Ernest Linwood Ohle

ERNEST LINWOOD OHLE, nominated for the office of Manager of The American Society of Mechanical Engineers, is professor of mechanical engineering and head of the department of mechanical engineering at Washington University, St. Louis, Mo. Professor Ohle was born in Berea, Ohio, in 1875. He attended Albion College, Albion, Mich., and Baldwin University in Berea, and later Case School of Applied Science, from which he received the degree of Bachelor of Science in mechanical engineering in 1902 and of Mechanical Engineer in 1905.

From 1902 to 1905 he served as instructor in mechanical engineering at Case, following which he became professor of steam engineering and head of the department of mechanical engineering at the State University of Iowa, where he remained three years. From 1908 to the present, Professor Ohle has been associated with Washington University as professor and head of the department of mechanical engineering.

In 1918 Professor Ohle served with the United States Shipping Board. For several years he was chairman of the Smoke Abatement Committee of the Civic League of St. Louis, and was first chairman of the advisory board on Smoke Abatement for the City of St. Louis, serving for three years. He has a special interest in researches in smoke abatement, soot fall, and air infiltration.

He has been a member of The American Society of Mechanical Engineers since 1906. He served as secretary of the St. Louis Section of the A.S.M.E. in 1909 and 1910 and as chairman in 1911–1912. He was a member of the Nominating Committee in 1916, and a member of the Committee on Constitution and By-Laws from 1921 to 1924, serving as chairman the last year. He is a member of Delta Tau Delta, Sigma Xi, S.P.E.E., A.A.U.P., the St. Louis Engineers' Club, and a fellow of the A.A.A.S.

James M. Todd

JAMES M. TODD, nominated for the office of Manager of The American Society of Mechanical Engineers, is engaged in the private practice of consulting mechanical and electrical engineering, New Orleans, La. He was born in 1896 in Franklin, La. He was graduated from Tulane University in 1918 with the degree of Bachelor of Engineering, and in 1930 received the degree of Mechanical Engineer. During the World War, Mr. Todd served as a Lieutenant of Engineers, seeing service in England and France. After the war he became chief engineer for Penick & Ford, Ltd., formerly of New Orleans, and now of Cedar Rapids, Iowa. From 1921 to 1928 he was associated as assistant engineer with A. M. Lockett & Company, mechanical engineering contractors, New Orleans, resigning to engage in private practice of consulting mechanical and electrical engineering. He has since been retained as consultant in mechanical and electrical problems by the Orleans Parish School Board, the Board of State Engineers, the City of New Orleans, and Tulane University. He has had a wide experience in the mechanical and electrical equipment of buildings and industrial plants.

Mr. Todd became a junior member of the Society in 1922 and a member in 1929. He is at present serving his second term as chairman of the Committee on Local Sections of the Society, is a member of the Committee on Registration of Engineers, and of the Committee on the Economic Status of the Engineer. He is a past-president of the Louisiana Engineering Society and a member of the American Institute of Electrical Engineers.

Economic Conference for Engineers

THE third Economic Conference for Engineers, under the auspices of Stevens Institute of Technology, the A.S.M.E., the American Institute of Chemical Engineers, and the alumni associations of Brown, Columbia, Cornell, Harvard, M.I.T., Princeton, Rensselaer, and Yale, will be held at the Stevens Camp, Johnsonburg, N. J., August 12 to 20, 1933. President Harvey N. Davis and Prof. William D. Ennis, of Stevens, will act as chairmen of the sessions. The general subject is "The Financial Situation." More than a dozen well-known economists, editors, financiers, and publicists will address the conference and lead in its discussions. A fee of forty dollars is charged for the full session. To enroll, or to secure further information, address The President's Office, Stevens Institute of Technology, Castle Point, Hoboken, N. J.

Guggenheim Medal Awarded to Commander Hunsaker

THE Daniel Guggenheim Medal, recognizing "notable achievement in the advancement of aeronautics," has been awarded for 1933 to Commander Jerome Clarke Hunsaker, vice-president of the Goodyear-Zeppelin Corporation, Akron, Ohio, for "contributions to the science of aerodynamics, to the science and art of aircraft design, and to the practical construction and commercial utilization of rigid airships."

The formal presentation of the medal will probably take place at a meeting of the Society of Automotive Engineers in Chicago late in August. Previous Guggenheim medalists have included Orville Wright, Ludwig Prandtl, of Germany, Frederick William

Lanchester, of England, and Juan de la Cierva, of England.

Oil and Gas Power Meeting Papers Now Available

IN THE July issue was published the program of papers to be presented at the Sixth National Meeting of the Oil and Gas Power Division of the A.S.M.E., at Atlantic City, N. J., August 23–26. These papers are now available and may be obtained by addressing the Oil and Gas Power Division, A.S.M.E., 29 West 39th St., New York, N. Y.

D. S. Kimball Awarded Lamme Medal

DEXTER S. KIMBALL, Dean of the College of Engineering, Cornell University, past-president, A.S.M.E., and past-president, S.P.E.E., was awarded the Lamme Medal at the annual banquet of the Society for the Promotion of Engineering Education during its 41st annual meeting, held at Chicago, Ill., during Engineering Week, June 25 to July 1. Dean Kimball is the sixth recipient of the medal, which is awarded each year by the Society "to a chosen technical teacher for accomplishment in technical teaching or actual advancement of the art of technical training." The award is named for its donor, the late Benjamin G. Lamme, formerly chief engineer of the Westinghouse Electric and Manufacturing Company.

Books by Gilbreth Wanted

THE Newark College of Engineering desires to acquire copies of the following books by the late Frank B. Gilbreth: Field System; Concrete System; Bricklaying System; Motion Study; Primer of Scientific Management; Time Study, the Science of Obtaining Methods of Least Waste.

These books will be placed in the Gilbreth Memorial Room which has been dedicated to the memory of this pioneer. The room now contains some of his papers, pictures, and instruments, and a fairly complete library of works on scientific management and human relations. Communications should be addressed to S. Fishman, Newark College of Engineering, Newark, N. J.

W. E. Wickenden Heads S.P.E.E.

AT THE 41st Annual Meeting of the Society for the Promotion of Engineering Education, held at Chicago, Ill., during Engineering Week, June 25 to July 1, William E. Wickenden, President, Case School of Applied Science, member, A.S.M.E., was elected president of the society for the year 1933–34. The two vice-presidents elected were Prof. F. V. Larkin, Director of Mechanical Engineering and Industrial Engineering, Lehigh University, member, A.S.M.E., and B. M. Brigman, Dean, Speed Scientific School, University of Louisville, member, A.S.M.E. Prof. F. L. Bishop, of the University of Pittsburgh, and W. O. Wiley, of John Wiley & Sons, New York, members, A.S.M.E., were reelected secretary and treasurer, respectively.

Members of Council elected were as follows: Karl T. Compton, President, Massachusetts Institute of Technology; Blake R. Van Leer, Dean of Engineering, University of Florida, member, A.S.M.E.; Fred E. Ayars, Dean, College of Engineering and Commerce, University of Akron; Prof. J. B. Finnigan, Armour Institute of Technology, Chicago, Ill.; Prof. C. H. Willis, Princeton University; W. N. Gladson, Dean College of Engineering, University of Arkansas; and Prof. H. B. Walker, University of California.

Opportunity for Engineers in New Building Program

PRIVATE architects and engineers throughout the country will be engaged by the Treasury Department to prepare the plans and specifications for a large Federal building program which may reach a total of $200,000,000. L. W. Robert, Jr., Assistant Secretary of the Treasury, has adopted this policy in order that professional men who have not had employment will benefit by the large expenditure for new Federal buildings, the design and construction of which come under the authority of the Supervising Architect's Office of the Treasury.

For the purpose of spreading employment as far as possible among architects and engineers who, preferably, have had some previous experience in public building work, Mr. Robert has requested the cooperation of the American Engineering Council and the American Institute of Architects in enrolling qualified individuals and firms. His purpose is to engage on every building architects and engineers resident in the state in which it will be erected.

The Treasury Department, with the cooperation of the American Institute of Architects, is assembling the records of architects throughout the country. Each known architect has or will receive a prequalification blank, which should be forwarded to reach the Treasury Department promptly.

As the procedure adopted for enrolling architects could not be utilized satisfactorily to obtain the same character of information concerning engineers, the American Engineering Council has been requested by Mr. Robert to compile state lists of engineers and engineering firms that customarily engage in construction of buildings of the monumental character usually typifying those built by the Federal Government.

Through its member organizations and other technical groups, the Council inaugurated its canvass several weeks ago. The lists are being prepared so that Council will be in a position to submit to the Treasury Department the names of competent engineers in any and all states when there is a call for the services which they are qualified to render.

Any qualified engineer desiring to participate in the Treasury Department's building program should send to L. W. Wallace, Executive Secretary, American Engineering Council, 744 Jackson Place, N. W., Washington, D. C., a complete statement, in duplicate, of his professional record, with a citation of significant references.

The American Engineering Council's function in enrolling engineers for the building program is to make available lists of competent engineers and firms and not to select and employ men. These are functions of the Treasury Department.

The American Engineering Council is gladly cooperating with the Assistant Secretary of the Treasury, Mr. Robert, and the American Institute of Architects in making available to engineers and architects in private practise construction work done under the direction of the Supervising Architect's Office.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after August 25, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

BAKER, ROY E., Boston, Mass.
BOUGH, CLIFFORD A., JR., Warren, Ohio
CARTER, GEORGE W., Salt Lake City, Utah
COLEMAN, L. G., New York, N. Y.
DANN, WILLARD J., Des Moines, Iowa
DAY, WILLIAM F., JR., Greenwich, Conn.
DAVLIN, LEO J., JR., Inglewood, Calif.
DICK, ANDREW V., Schenectady, N. Y.
DWYER, EDWARD J., E. Norwalk, Conn.
EHRHART, GEORGE, Glendale, Calif.
ERSKINE, JAMES H., University, N. C.
FAILMEZGER, EUGENE, Syracuse, N. Y.
FAWCETT, HOWARD N., Ossining, N. Y.
FIERRO, SANTOS, Mexico D. F., Mex.
HAVER, CLINTON E., Brooklyn, N. Y. (Rt)
HOULD, GEORGE F., Malta, Mont.
HOWARD, HENRY S., Oakland, Calif. (Rt)
HUNSAKER, J. C., New York, N. Y.
JACKSON, L. R., Louisville, Ky.
KLUESENER, HUGO H., Newark, N. J.
KOCH, H. G., Pelham, N. Y.
KOONTZ, LAMONT B., Deer Lodge, Mont.
MADDEN, JOHN A., Oakland, Calif.
MARTIN, CHARLES H., Holbrook, Mass.
MATTAEUS, A. H., Boise, Idaho
MAYSE, GEORGE F., Azusa, Calif.
MILLER, GEORGE E., Ravenna, Ohio
MILLER, HARRY PALMER, JR., Brooklyn, N. Y.
MONK, DONALD J., Lamona, Wash.
MURRAY, CHARLES P., Elma, Wash.
NOYES, MASON S., Washington, D. C.
PETRI, WILBUR J., Milwaukee, Wis.
RING, VINCENT P., Belleville, Ill.
ROWLAND, RICHARD H., Chicago, Ill.
RUSINKO, MICHAEL F., Edgewater, N. J.
SCHOEMAN, J. P., Randfontein, Transvaal, South Africa

STEENWERTH, CHARLES F., Sanford, Fla.
STITT, WILLIAM T., Ft. Worth, Tex.
TATE, BENJAMIN E., JR., Dayton, Ohio
TEALL, CHARLES H., Weedsport, N. Y.
THOMSON, HUGH M., Salt Lake City, Utah
TRASHUTIN, I., Cambridge, Mass.
VAN KLINK, J., Enka, N. C.
WEINLAND, CLARENCE E., Manville, N. J.
WITTMAN, LAWRENCE, New York, N. Y.
WOOD, REGINALD D., State College, Pa.
WRIGLEY, GROVER W., Santa Ana, Calif.
ZERMAN, CHARLES W., Upper Darby, Pa.

CHANGE OF GRADING

Transfers from Associate-Member
BARRY, ELMER D., British Guiana, S. America
Transfers from Junior
BOLTIZAR, ALBERT L., Brooklyn, N. Y.
DOWLING, DONALD L., Ridgewood, N. J.
FALES, HERBERT G., West Newton, Mass.
GARRISON, RANALD M., Houston, Tex.
KASSEBOHM, WALTER, Emeryville, Calif.
LOESER, OSCAR E., JR., Mountain View, Calif.
STRATE, JOSEPH T., Brookings, S. D.

Cooperative Research at Oklahoma University

THREE major research problems, relating to the petroleum industry, are being carried out at the Experimental Engineering Laboratories of Oklahoma University, Norman, Okla., under the sponsorship of The American Society of Mechanical Engineers. The tests in connection with projects are being conducted by senior engineering students under the personal supervision of Prof. W. H. Carson, head of the Department of Mechanical Engineering.

The tests now in operation are: (1) Oil-metering tests, sponsored by the Fluid Meters Subcommittee of the A.S.M.E. Special Research Committee on Fluid Meters; (2) Efficiency and capacity tests of steam-driven slush pumps and superheat oil-field boilers; and (3) Diesel anti-knock tests.

The oil-metering tests include the testing of the accuracy of the existing coefficients and correction factors for the flow of oils through orifice plates, flow nozzles, and venturi throats at varying viscosities, temperatures, and velocities. Professor Carson and other members of the Fluid Meters Subcommittee have gone to great pains to devise special manometers, reading devices, means of connection, and set-up to make the results obtained the most accurate possible; and since the personnel of this committee consists of representatives of both manufacturers and users from various parts of the country who have had much experience in metering problems, the results will be accepted by the industry as the criterion for any tests to be made in the future. In arriving at the proper set-up and procedure for these tests, the committee has not once sacrificed possible accuracy for speed or more necessary equipment.

The tests on the efficiency and capacity of the boiler and slush pump are sponsored by the A.S.M.E. Special Research Committee on Rotary Drilling of Oil Wells and are being conducted under the personal supervison of Prof. W. H. Carson. The report on the completed tests is to supplement the "Report of Tests on Steam Equipment for Drilling Rotary-Drilled Oil Wells," recently published by the A.S.M.E., data for which were collected and computed by Professor Carson. The tests on the slush pumps and boilers will include actual steam consumption by the slush pump while using muds of various weights and at varying pressures, efficiencies of the boilers and slush pumps in actual operation, and a complete laboratory test of the pumps. The slush pit is equipped with a weir and weir coefficients for all weights of mud will be determined.

The third project, Diesel anti-knock testing, is being sponsored by the Oil Transportation Committee of the A.S.M.E. Petroleum Division and conducted by Professor Carson. For this test a special machine had to be devised, and this was done by placing a special head on a regular ethyl anti-knock testing machine. Results of these tests will be of benefit to all users of Diesel engines.

A fourth test now being considered is that of various types of oil-well pumps. The Subcommittee on Oil Lifting Methods of the Production Committee of the A.S.M.E. Petroleum Division has made a study of the various types of pumps, and before submitting its report, wishes to make some actual tests. Equipment is now in place at Oklahoma University where these and other oil-lifting tests can be made.

Committee on Fluid Flow in Pipe Lines Begins Its Work

THE Transportation Subcommittee on "Fluid Flow in Pipe Lines" of the Petroleum Division of The American Society of Mechanical Engineers inaugurated its work at a meeting on Friday morning, May 12, in the offices of W. G. Heltzel, the Division chairman.

The objects of this work are: (1) To arrive at a basic formula for calculations of fluid flow in a single line. (2) From the start of the single-line formula, to derive a formula for loops, equivalent diameters, and equivalent lengths, determining the limiting range for calculation of equivalent diameters which will result in values of $D v \rho / \mu$ giving points on that part of the turbulent-flow curve having the same slope, and to check results obtained by calculation of the formula against actual results obtained on at least ten separate systems. (3) To establish a curve for the determination of the friction factor f, pointing out the practical working range, and from experimental data gathered on work and tests to be conducted on ten separate lines, following a definite procedure recommended by the committee, to differentiate the slopes of the curves as indicated by turbulent flow for different values of $D v \rho / \mu$. (4) To establish tables for values of f, and also to establish viscosity charts. (5) To design a slide rule for hydraulic calculations. (6) To establish and maintain a bibliography on fluid flow in pipe lines. (7) To determine the causes of collection of paraffin on the walls of the pipes, and whether this condition is a function of pipe diameter and whether it can be remedied by hydraulic means. (8) To explore the cross-section of pipe at various points for velocity rates of the stream all the way across. (9) To determine and evaluate the problems of pumping heated oils. (10) To limit the committee work at the outset to problems in crude oil, after which the work will continue along the same lines on crude-oil derivatives, including gas, gasoline, etc.

The aforementioned problems were selected for the reason that the various companies use equally as many sets of curves, coefficients, and methods of calculating and designing oil pipe lines, based entirely on coefficients developed by individuals, and because pipe-line engineers have long recognized that the coefficient of friction losses, as expressed in the tables, formulas, and curves of the "Standards," published by the Hydraulic Society, is too high and cannot be used satisfactorily for the design of large trunk lines involving a considerable expenditure. Since the trunk-line systems of the various companies present the best laboratory available for the accurate determination of coefficients, leading pipe-line engineers concur in the opinion that there is a possibility of being misled by the discrepancies in data obtained in small short-line laboratories that in most cases use small diameter pipe, but that the most valuable data yet recorded in this work could be obtained by the coordinated efforts of the pipe-line companies.

The cooperation of the Hydraulic Society in this undertaking has been assured by V. P. Gerbereux, and it is likely that publication of revised and corrected data on friction coefficients for oil pipe lines in the "Standards" will be withheld until results of this work are obtained.

The committee intends to make this valuable information available to any one caring to use it, and it is deemed especially helpful to small companies that have had no extensive experience in designing large pipe lines, as by proper design, several miles of loop lines and other expensive equipment may be saved at the outset.

The attendance at the meeting included: W. G. Heltzel, chairman, Stanolind Pipe Line Co.; H. F. Brindel, Gypsy Oil Co.; Stanley Learned, Phillips Co.; J. M. McGregor, MacAdam Co.; Floyd Warterfield, Oklahoma Pipe Line Co.; L. E. Davis, Sinclair-Prairie Co.; D. C. Brown and J. J. Boyd, Stanolind Pipe Line Co.; and Harold Adkison, A.S.M.E. Members of the committee not in attendance are: R. W. Hendee, Oklahoma Natural Gas Co.; Oscar Wolf, Texas Co., New York City; and Emory Kemler, University of Pittsburgh, Pittsburgh, Pa.

Industrial Relations Conference at Silver Bay

THE Sixteenth Annual Conference on Industrial Relations will be held at Silver Bay, Lake George, N. Y., August 23 to 26, under the auspices of the Industrial Department of the National Council of Y.M.C.A.'s. The subjects to be discussed will center around recent social and industrial legislation. For registration and further information address E. C. Worman, secretary, 347 Madison Ave., New York, N. Y.